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The Journal of HEREDITY

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CHESTNUT HYBRIDS

A WALTZING RABBIT

INTELLIGENCE AND RACE

ANOTHER HEN THAT CHANGED COLOR

BACK CROSSES IN SMALL-GRAIN BREEDING

DIVERSITY OF INTERNODE INDIVIDUALS

THE CULTURE OF CREPIS

BEAVER FARMING

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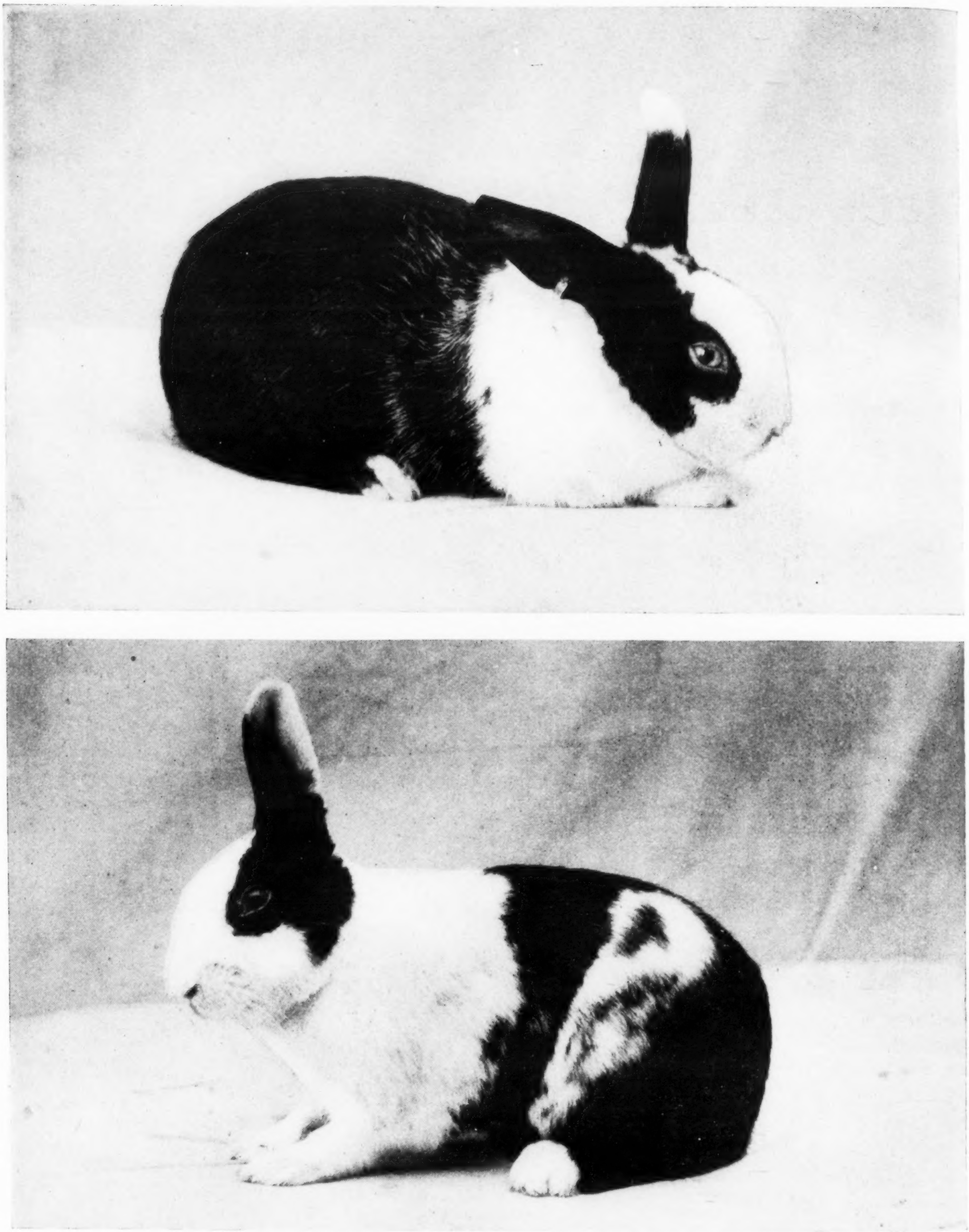


THE WALTZING RABBIT

FRONTISPIECE. One of *Waltzer's* ancestors was used in experiments to determine whether lead poisoning injures the germ plasm. Another was used in similar experiments in which alcohol was the toxic agent. Have these poisons permanently injured the germ plasm of this family of rabbits, causing the defective nervous system that characterizes *Waltzer* and some of his relatives, or has the inbreeding that has been practiced brought to light a latent defect of the germ plasm, as inbreeding often does? This is a question of very real importance to us as well as to the rabbits. If the lead used in many industries and the alcohol consumed by the opponents of the Eighteenth Amendment result in permanent injury to the race, it is something that every patriotic citizen, interested in the future of the nation, needs to know.

A WALTZING RABBIT[1]

LEON J. COLE AND DEWEY G. STEELE

Department of Genetics, Wisconsin Agricultural Experiment Station, Madison

AMONG a litter of four rabbits born February 14th, 1916, one later developed the habit of "waltzing" very much as is characteristic of the waltzing mouse. The peculiar actions of this animal were so pronounced and continuous as to attract the attention of all visitors. Darbishire early demonstrated the definite inheritance of this trait in the mouse, and when a similar condition was later discovered in rats by Bonhote,[2] this also was found to be inherited as a Mendelian recessive.

It at once became a matter of interest, therefore, to find whether we had another case of the same sort in rabbits. This led to a careful study of the pedigree of this individual for a clue as to how the trait may have originated, and to extensive breeding tests; but before giving these it will probably be best to describe more fully the individual himself and his behavior.

Waltzer, as he came to be called (or ♂ 301.3 of the records) was a strong, vigorous male of normal growth, but with a defective iris in the left eye and a tendency to carry the head turned a little to one side, the left. The iris of the left eye was incomplete on the lower side, making the pupil appear elongated vertically. It was probably the close approach of the pupil to the lower lid in this eye that gave it the appearance of always being partially closed (compare the two views, which show the right and left sides of the animal, respectively). In temperament *Waltzer* seemed more nervous than the average rabbit, and if disturbed or excited in any way would usually turn round and round in his pen in a narrow circle not much greater in diameter than the length of his body. He also often exhibited the circus movement of his own accord when not disturbed, but was able to hop ahead in a straight line when it seemed to suit his pleasure. When traveling directly in this way he did not exhibit the "wobbly" movements so characteristic of the waltzing mice. While he circled to the left (counter clockwise) much more often than to the right, he did, nevertheless, often turn in the other direction. This rabbit also frequently made a peculiar low grunting noise, different from any commonly made by rabbits.

Waltzer's Ancestors

The pedigree of *Waltzer* (Chart I) exhibits a number of points of considerable interest. Three generations back in his paternal lineage he traces to two original pure-bred Dutch-marked rabbits (♂ 14.1 and ♀ 15.1), purchased of a breeder who made a specialty of them. It is to be noted that the male (14.1) was used in connection with experiments on the effects of alcohol,[3] and is accordingly marked "alcoholized." Male 20.2, one

[1] Papers from the Department of Genetics, Wisconsin Agricultural Experiment Station, No. 37. Published with the approval of the Director of the Station.

[2] BONHOTE, J. LEWIS. On waltzing rats. *Proc. Zool. Soc. Lond.* 1912, pp. 6-7. It is of interest in the present connection to note Bonhote's report that "apart from the 'waltzing' character, three individuals were born blind, and in two of these cases the eyes were undeveloped and the optic nerve absent, and in addition many of the young that were reared were so weakly that they had to be killed, and others died before being weaned."

[3] COLE, L. J., and C. L. DAVIS. "The effect of alcohol on the male germ cells, studied by means of double matings." *Science* (N. S.), Vol. 39, No. 1004, pp. 476-77. 1914.

of the offspring of this original pair, was also used in an experiment in which poison was administered, this time in the form of lead acetate.[4] He finally died with symptoms of lead poisoning. The ancestry of the female, designated 1A (298.1), to which 20.2 was bred, is not accurately known, and the same is true of 3A (296.1) and 2A (297.1), which occur on the maternal side of *Waltzer's* pedigree. A number of young rabbits were discarded before being marked with ear tags, and these three were later returned to the breeding pens. There is much reason to believe that they are closely related to one another, possibly even being litter mates, and that they are all descended from ♂ 14.1. This presumption is based on color markings and other known facts, but the relationship cannot be asserted.

The mating of 20.2 and 1A (298.1) gave rise to 299.3, the father of *Waltzer*, who was, so far as the records show, an entirely normal rabbit. *Waltzer's* mother (274.6) was also normal, but her father, 3A (296.1), when about half grown acquired a deformity recorded as "probably spinal trouble." Later this seemed to be complicated by other nervous disturbances so serious that he was disposed of. The mother of 274.6 was 2A (297.1), which was normal, and concerning the ancestry of which there is uncertainty, as has been stated.

Discussion

Summarizing *Waltzer's* pedigree, then, we find first the possibly significant fact that his paternal grandsire and great grandsire were poisoned by drugs reputed to have a deleterious effect on the germ plasm, and

CHART I. *Pedigree of "Waltzer"*

- ♂ **301.3** "Waltzer"
  - ♂ 299.3
    - ♂ 20.2 (leaded)
      - ♂ 14.1—original purebred Dutch (alcoholized)
      - ♀ 15.1—original purebred Dutch
    - ♀ 1A (298.1)—Probably descended from 14.1
  - ♂ 274.6
    - ♂ **3A (296.1)**—Showed deformity, "probably spinal trouble," when about half grown. Later seemed to suffer other nervous complications and was killed. Probably descended from 14.1
    - ♀ 2A (297.1)—Probably descended from 14.1

CHART II. *Pedigree of Litter* 328

- ♀ 328.1
- ♂ **328.2**—paralyzed; killed when about 7 months' old
- ♀ 328.3
- ♀ 328.4
- ♂ 328.5
- ♂ 328.6
- ♂ **301.3** "Waltzer"
  - ♂ 299.3
    - ♂ 20.2
    - ♀ 1A (298.1)
  - ♀ 274.6
    - ♂ **3A (296.1)**
    - ♀ 2A (297.1)
- ♀ 293.3
  - ♂ **3A (296.1)**
  - ♀ 299.1
    - ♂ 20.2
    - ♀ 1A (298.1)

[4] COLE, L. J., and L. J. BACHHUBER. "The effect of lead on the germ cells of the male rabbit and fowl as indicated by their progeny." *Proc. Exper. Biol. and Med.*, Vol. XII, pp. 24-29. 1914.

second, that if the other grandparents are related as believed, there has been a considerable amount of inbreeding. The only record of any nervous defect in his pedigree is that of his maternal grandfather as noted.

A search of the records for other cases of possible nervous abnormality has revealed three such, and it would seem more than coincidence that they should all show relationship to the pedigree already given. This fact is emphasized when it is recalled that the records include hundreds of animals, many of which are related in one way or another to the descendents of 14.1 and 15.1, but many others which are in no way related to them.

An albino, own son (♂ 327.4) of *Waltzer*, produced by breeding him to his full sister (♀ 307.7) from a subsequent litter, exhibited a behavior somewhat similar to that of his father, but in a much less degree. This male was one of a litter of five born February 9, 1917, and the records contain the following note made February 26, 1918, when he was a year old. "When excited this animal shows a tendency to waltz similar to that of its father ♂ 301.3, though never makes but a turn and a half at one time. He makes a noise like that of 301.3." This male had two litters of young by related females and one by a female apparently unrelated, but no defects are recorded among the offspring.

Another of the individuals referred to was also a son of *Waltzer*, as shown in Chart II. This was a male in a litter (328) of six young, consisting of three males and three females, and was recorded as killed when about seven months of age because paralyzed. He is the only one in the litter mentioned as being in any way abnormal. The inbreeding in this case is again very pronounced; *Waltzer* was mated to his cousin, mate of *Waltzer's* father, and whose father was also *Waltzer's* maternal grandfather.

The third individual, which was likewise killed at about seven months of age because paralyzed in the hind parts, is shown in Chart III. Here again the same blood is found, the affected individual (♂ 374.7) being a grandson of 3A (296.1).

If we were to speculate on the basis of the charts here presented we might be tempted to conclude that the evidence points to the production of a germinal nervous defect of at least some general sort as a result of the treatment of males 14.1 and 20.2, either one or both. Further, that this inducted trait tends to be recessive, and as such traits do, to reappear as a result of inbreeding. And finally, we might go so far even as to suggest that since the nervous defect has shown itself only in males (the affected individuals are indicated in the charts by black face type), it is the sex chromosome which has been affected and the character is of the nature of a sex-linked recessive.

There are other facts, however, which would make such conclusions from the present data hazardous, to say the least. For one thing, it is by no means certain that the circus movements of *Waltzer* and his son 327.4, and the various degrees of paralysis of the others are to be referred to the same germinal cause, nor indeed, for that matter that they are necessarily germinal in origin. In the second place, the number of individuals which showed any sort of

---

CHART III. *Pedigree of Paralyzed Rabbit* 374.7

♂ **374.7**—killed at about 7 months of age because paralyzed in hind parts

- ♂ 274.3
  - ♂ **3A (296.1)**
  - ♀ 2A (297.1)
- ♀ 2A (297.1)

unusual nervous disturbance was far too small for any simple Mendelian explanation, certainly; for, although *Waltzer* was bred to as many related females as possible, and the progeny were mated back to him and together among themselves, only one other individual with anything of his characteristic behavior was obtained. The records do not show at what age *Waltzer* began his dancing, but the cases of paralysis apparently did not come on until the rabbits were several months old. Since many of the youngsters died or were disposed of at an early age this might result in a considerable number of potentially defective individuals never reaching record. Finally the supposition that such disturbances as were found are to be attributed to the treatment of 14.1 and 20.2 is at most presumption, for it is possible that there was a latent nervous defect in the original stock when obtained.

All in all, however, we are inclined to feel there is a fair presumption that the behavior of *Waltzer* and the other affections may be attributed at least indirectly to either the lead or the alcohol treatment, and that they were probably the result of some germinal effect, but one of a rather general nature, not specific, at least in its manifestation. At any rate, the data seem to establish that while the waltzing of this rabbit resembled closely that of the mouse and rat, it certainly does not seem to be the same in inheritance. To what extent the circus movements induced in rats by rotation resemble in inheritance those found in nature we do not know, but the findings of Griffith, as presented by Detlefsen,[5] show a high incidence of circus movements among the descendants of rats which have been rotated.

Waltzer lived to the ripe old age (for a rabbit) of five years and ten months. In the latter part of his life he became less active and did not "dance" so frequently. In the last three months he was seen to whirl in his characteristic manner only once, and this was when he had fallen a distance of nearly five feet from his cage to the floor, which apparently excited him to the point of losing nervous control—if that is what his whirling signified. The poor fellow finally had an infection causing a swelling of his head and neck and involving his eye, and it seemed an act of mercy to put him out of his misery. At most, he probably could not have lived more than a few days, or possibly weeks, longer.

[5] At Toronto meeting of the American Society of Naturalists, December 29, 1921.

INTELLIGENCE AND RACE

A REVIEW OF SOME OF THE RESULTS OF THE ARMY INTELLIGENCE TESTS.—II. THE NEGRO

PAUL POPENOE
Coachella, California

IN tabulating the results of army tests of intelligence, the psychologists of the Surgeon General's office took a sample of 18,891 negroes for the purposes of analysis.[1] This gives a more nearly accurate picture of the negro population of the United States than any study hitherto made. While the inferences drawn from an examination of these records bring to light nothing previously unknown, they are of extraordinary value for the confirmation they give to conclusions earlier reached by many investigators, from other lines of evidence, regarding the mental status of the so-called colored population of the United States.

For the most part, the army statistics do not differentiate between full-blood negroes and mulattoes, and unquestionably a large part of the so-called negroes of the draft have white blood, often to a preponderant extent. The results must be interpreted with this fact in mind, for it is established that the intelligence of a "colored man" depends to a marked degree on the amount of white blood he has.[2] This conclusion, reached by several previous investigators, and supported by the verdict of "common sense" observation, is confirmed by several studies of the army psychologists.

At Camp Lee, for instance, "the experiment was tried of separating some of the negro recruits on the basis of skin color and comparing the intelligence ratings obtained from the lighter and darker groups. The report describes the experiment as tried on two battalions of negro recruits as follows: 'The lighter class contained those whose color indicated that they were true mulattoes or persons with a larger proportion of white blood than true mulattoes. The darker class contained pure negroes and those whose skin color indicated that they had a smaller proportion of white blood than true mulattoes. The classification was made by the various examiners of the groups.

"'In alpha [one of the standard army tests] the lighter negroes obtained a median score of 50; the darker a median score of 30. In beta [another standard test, devised particularly for illiterates and persons unable to speak English] the lighter negroes obtained a median score of 36; the darker obtained a median of 29.'"

In the data which I am about to present, therefore, it must be borne in mind that the showing of the negroes is improved by the presence of much white blood in many of them; and that to get at the real ability of the black man one would have to subtract no small amount from all of the scores to be mentioned.

Geographical Distribution of Intelligence

This fact undoubtedly has a bearing on the significant revelation of the tests, that the negroes in the Northern States are, on the average,

[1] *Memoirs Nat. Acad. Sci.* XV (1921) pt. III, Ch. 8.

[2] Apparently the same holds good for American Indians with various amounts of white blood. See the studies reported by Professor Hunter and Mr. Garth at the 1920 meeting of the *American Psychological Association*, in Chicago.

more intelligent than those of the Southern States. The cleavage is so marked as to lead one of the examiners (at Camp Dix) who made a study of 3,127 negroes of the July draft, to comment that "in general the Southern negro is as much inferior to the Northern negro as the negroes are inferior to the whites."

The negroes of Ohio made the best showing; those of South Carolina the worst. The great differences may be indicated by the fact that of two groups selected for study, the Northern negroes had 3.4% of A and B grades, with 45.6% of of D and D-, while the Southern negroes (from Alabama, Georgia, Louisiana and Mississippi) had but .03% in the A or B classes, and 86.2% in D or below.

How is this difference to be explained? It was found that the Northern negroes had less illiteracy, and conversely more education than those in the Southern groups. But since education is productive of results only to the extent that it has material to work on, one need feel no hesitation in concluding that the Northern negroes are inherently superior to the Southern; and two principal reasons suggest themselves. In the first place, it is possible that the Northern contingent represents a larger infusion of white blood than those who remain in the South; in the second place it seems certain that the more energetic, successful, and able of the Southern negroes are those who have had the ability and courage to break away from their home environments and come North; hence a selective influence has been at work to differentiate the two groups. But, to judge from all the studies available, the greater energy and ability of this group must be closely correlated with greater amounts of white ancestry.

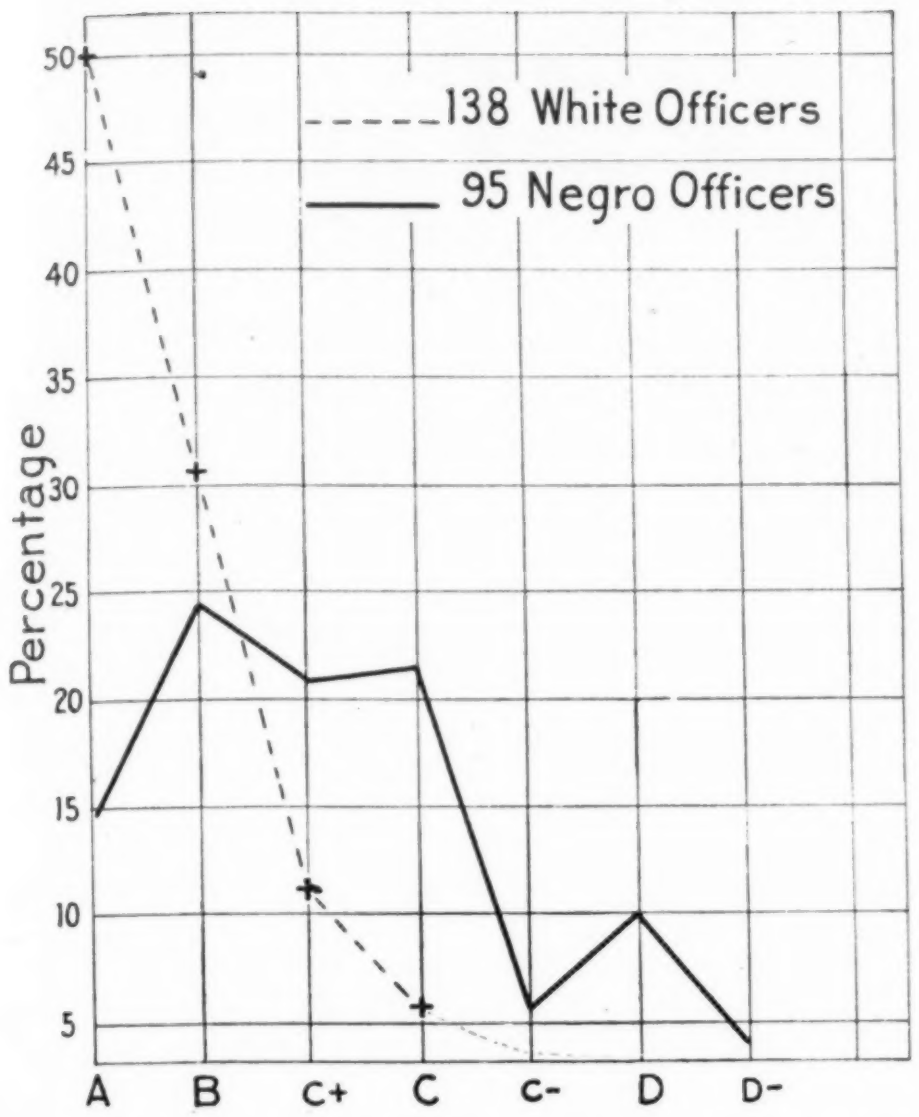
Just how great the difference between pure white and pure negro is, must, so far as these figures are concerned, be decided largely by inference, for the reason above noted, that most of the records, even of Southern negroes, apply to members of the race, many of whom have more or less white blood, and are therefore more favorable to the negro stock than actual facts warrant. It would be interesting to know whether the negro officers were, on the average, noticeably lighter in color than the negro in the ranks. It seems probable that they were, since their superiority to their fellows is marked; indeed, the negro officers, who represented a highly selected lot, represent almost the same distribution of intelligence as the average of the entire white draft. When the negro officers are compared with a white group equally selected—namely, the white officers—the true comparison is made and graphically shown in figure 1.

While the evidence seems to warrant the conclusion that qualitative differences between the negro and white minds do exist, the greatest difference is unquestionably merely one of degree. The average mental age of the white draft army was 13.08 years; the average of the negro was that of a normal white child of 10.37 years.[3] For adults this degree of intelligence would place a white man definitely on the "border-line" of feeble mindedness.

Naturally, the army examiners were concerned mainly with the negro's fitness for military service. But, as the report observes, with the white men the tests were used to detect and eliminate those not good enough for service; while with the negroes they served more to detect the few who were good enough for service.

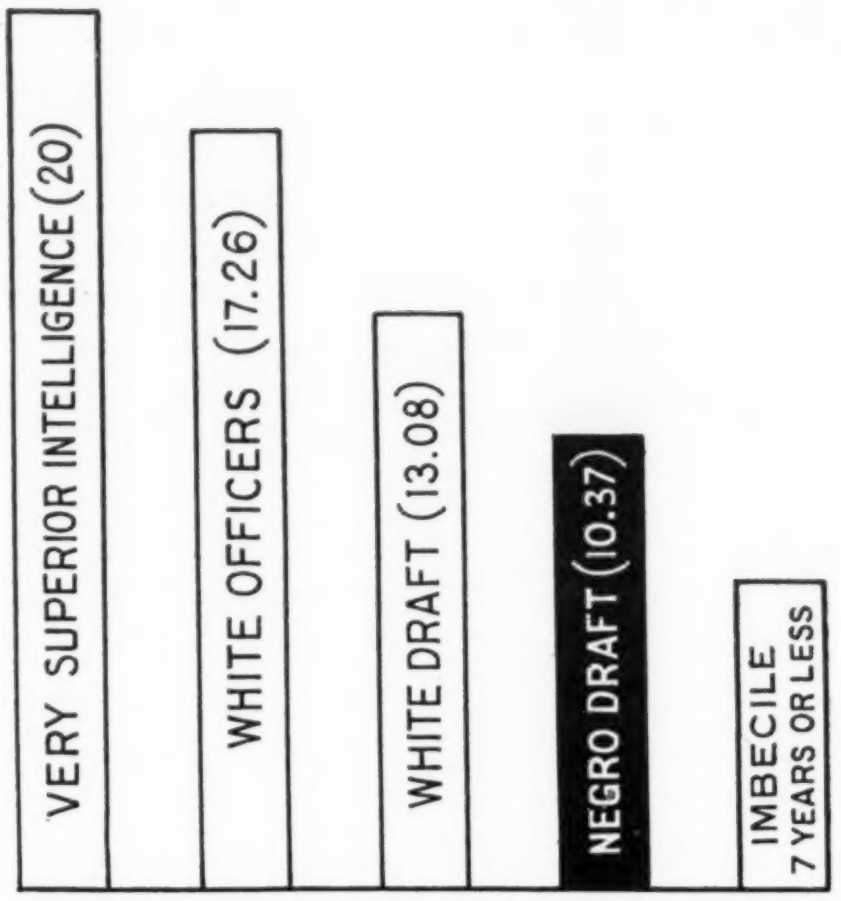
More specific information was sought at Camp Upton, where the company commanders were requested by the chief psychological examiner to make out, with the assistance of their lieutenants and first sergeants, a list of 50 negro recruits, 10 of whom, in their estimation, fell in each

[3]The curve for negro literates is close to that for white illiterates.



NEGRO AND WHITE ARMY OFFICERS

FIGURE 1. These curves, representing mental tests of negro and white American army officers, show clearly the differences in their intelligence. Both groups were highly selected, but the negro group probably represents a more stringent selection from the whole negro population, than the white group does from the white population. The negroes are not only inferior in average intelligence, but they show a small proportion of very superior men, as compared with the whites.



THE RANGE OF INTELLIGENCE

FIGURE 2. In the graph above, the length of the columns represents the mental age of the groups named, on the conventional scale, now widely used, in which 20 years is taken as indicating very superior adult intelligence, and 16 years as the intelligence of the normal adult. An adult who has the mentality of the normal 7-year-old white child would generally be regarded as an imbecile, or very low grade feeble-minded. The negro drafted men, on the average, are about half-way between this point and the general level of the white draft, which in itself was nearly three years below the level that has hitherto been taken as the standard of normal adult intelligence.

one of the following five designated classes:

A. Very superior. Equal to good white sergeant or white officer material.

B. Superior. Level of good white non-commissioned officers.

C. Level of good white privates; the large average group of the white draft.

D. Inferior. Only just good enough to make a satisfactory soldier.

E. Very inferior. Too poor to make a satisfactory soldier.

The results of the investigation are summarized as follows:

"(a) Less than 2% of negroes are of A value to military service when compared with white troops.

"(b) About 25% are considered by their officers as 'too poor to make a satisfactory soldier.' Most of them are D intelligent or less.

"(c) Nearly all the negroes who rate D- or E in intelligence and about half of those who rate D in intelligence are 'too poor to make a satisfactory soldier.'

"(d) D- intelligence is seldom more than just barely satisfactory."

The correlation between estimated military value and intelligence rating, as measured by the tests, was worked out and found to be .6.

These estimates are open to the charge that they were made by white officers, and therefore subject to the bias of race prejudice. Written comment of the officers was invited and is summarized as follows:

"(a) All officers without exception agree that the negro lacks initiative, displays little or no leadership, and cannot accept responsibility. Some point out that these defects are greater in the Southern negro.

"(b) All officers seem further to agree that the negro is a cheerful, willing soldier, naturally subservient. These qualities make for immediate obedience, although not necessarily for good discipline, since petty thieving and venereal disease are commoner than with white troops."

These conclusions as to the negro's relative inferiority for responsible military service are apparently borne out by the service records of the negro regiments sent to France.

As the conclusions of the army tests agree with those made under other auspices, it may be taken as certain that the negro is, as measured by intelligence tests, markedly inferior to the white men among whom he lives. Is this inferiority an innate and ineradicable condition, or is it, as some have supposed, merely a handicap due to unfavorable tradition and environment?

Professor Johnson and I have elsewhere pointed out the historical indications that the negro's low mental estate is irremediable.[4] If the number of original contributions which his race has made to the world's civilization is any fair criterion of its relative value, then the negro must be placed near zero on the scale.

"The following historical considerations suggest that in comparison with some other races the negro race is germinally lacking in the higher developments of intelligence.

"1. That the negro race in Africa has never, by its own initiative, risen much above barbarism, although it has been exposed to a considerable range of environments and has had abundant time to bring to expression any inherited traits it may possess.

"2. That when transplanted to a new environment—say Haiti—and left to its own resources,[5] the negro race has shown the same inability to rise; it has there, indeed, lost most of what it had acquired from the superior civilization of the French.

"3. That when placed side by side with the white race, the negro race again fails to come up to the higher standard, or indeed, to come anywhere near it. It is often alleged that this third test is an unfair one; that the social heritage of slavery must be eliminated before the negro can be expected to show his worth. But contrast his career in and after slavery with that of the Mamelukes of Egypt, who were slaves, but slaves of good stock. They quickly rose to be the real rulers of the country. Again, compare the record of the Greek slaves in the Roman republic and empire, or that of the Jews under Islam. Without pushing these analogies too far, is not one forced to conclude that the negro lacks, in his germ-plasm, some qualities which the white races possess, and which are essential for competition with the civilizations of the white races of the present day?"

The mental tests strongly support this conclusion; for they measure traits which are largely independent of schooling. They point clearly to the fact that the observed inferiority of the negro is to a large extent one which no amount of education, or favorable environment can obviate. While there are many bright negroes, and many dull whites, the average of the two races is measurably different. The negro is mentally, therefore eugenically, inferior to the white race.

All treatment of the negro, in the United States or elsewhere, must take into account this fundamental fact.

[4] *Applied Eugenics*, by Paul Popenoe and Roswell Hill Johnson, New York, 1918, p. 284.

[5] "The most satisfactory settlement of this discussion may be found, I believe, in a careful study of the negroes of Liberia, a state founded with free negroes, a state in which the negroes have been allowed full and free expression of their inheritance, in a natural climate, where advice of the whites has been available, but their blood has been withheld. Surely here, if anywhere, at the present time one should be able to observe the negro's possibilities, unhampered by slavery or race oppression."—Harris, Reginald G. "Eugenics in South America." *Eugenical News*, vii, p. 28, March, 1922.

A BLACK LEGHORN WHICH TURNED WHITE

F. A. E. Crew

Animal Breeding Research Department, University of Edinburgh, Scotland

ON June 24th, 1921, a Black Leghorn hen was sent to this Department by Mr. A. Backhouse, of Pontefract, in response to an appeal for "hens which had assumed the characters of the male." She was then eighteen months old, belonged to a heavy laying strain and had herself a very satisfactory egg-yield. During the three months previous to her arrival here, her comb had become progressively larger and more and more erect. She began to crow, not lustily, nor with a challenging note, but like a youngster practising. Her plumage was entirely black and hen-like, her spurs mere buttons (5½ mm.); her sexual behavior was that of indifference: she did not behave as a cock towards hens, nor as a hen towards a male. The most remarkable features were her large erect comb, measuring 11.6 cms. x 8 cms., and her weak effortful crowing, to perform which it was necessary for her to fly on to some high place. She did not perform any of the wing-flapping actions of the male when about to crow.

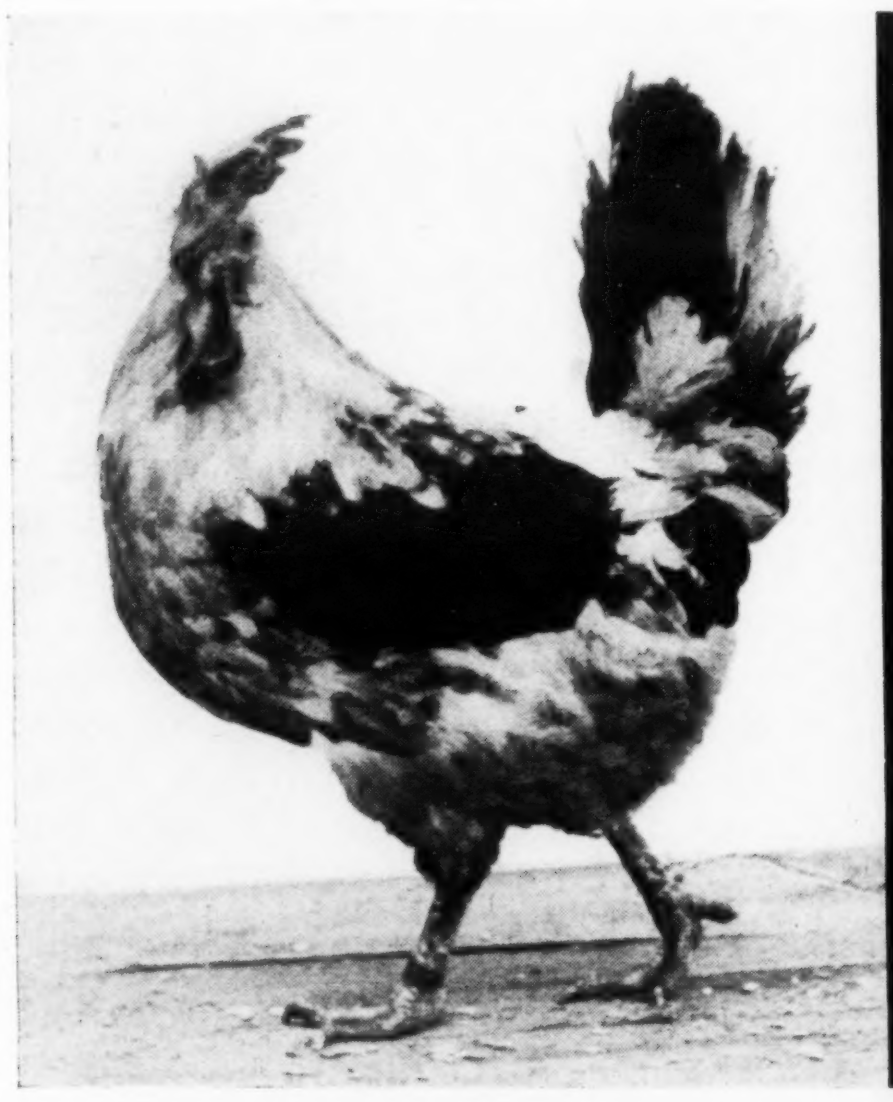
As she was allowed the freedom of the yard, her wing primaries were cut. During August she began to moult and the neck hackle, those primaries which were missing when the wings were clipped, and some of the fluff were replaced by feathers which were mainly white but had irregular "washed-out" black centres. The vascular tissue of the head furnishings became more and more congested. During the next year she moulted steadily and each feather as it was lost was replaced by a still whiter one, until at the time of her death in October, 1922, she was a white bird with a few irregular splashes of vestigial black. It was noted that the primaries which were clipped were not moulted until a year had passed. A few of the neck-hackle and saddle-hackle feathers were definitely cock-like in appearance and structure. During the later months of her life she became progressively more quiet, ceasing to crow and seeking solitude.

Postmortem examination showed that she had died from internal haemorrhage. Occupying the situation of the ovary was a large tumor the surface of which was invested by a mesh of dilated tortuous veins, one of which had ruptured. The tumor, weighing 103.4 grammes, measured 7.5 x 6.3 cms. and was blood colored. On one surface an area of what seemed to be ovarian tissue was found, the rest of the tumor had the form of a solid fleshy mass. The oviduct was as small as that of a resting bird.

On section, the ovarian portion of the tumor proved to be completely atrophic, no trace of germinal tissue could be found and only in one section could follicular remains be identified; these consisted of a mass of vacuolated cells encapsuled by connective tissue and attached to the rest of the ovary by a fibrous cord containing groups of luteal cells, and probably representing an old discharged follicle. With this exception the ovarian part of the tumor consisted entirely of connective tissue stroma, the peripheral parts of which were mainly cellular, whilst the inner (sex cord) region consisted almost wholly of white fibrous tissue. The interstices and folds of the ovary were packed with erythrocytes derived from the haemorrhage which caused the death of the bird. Luteal tissue was present in the form

January 24, 1921

September 15, 1921

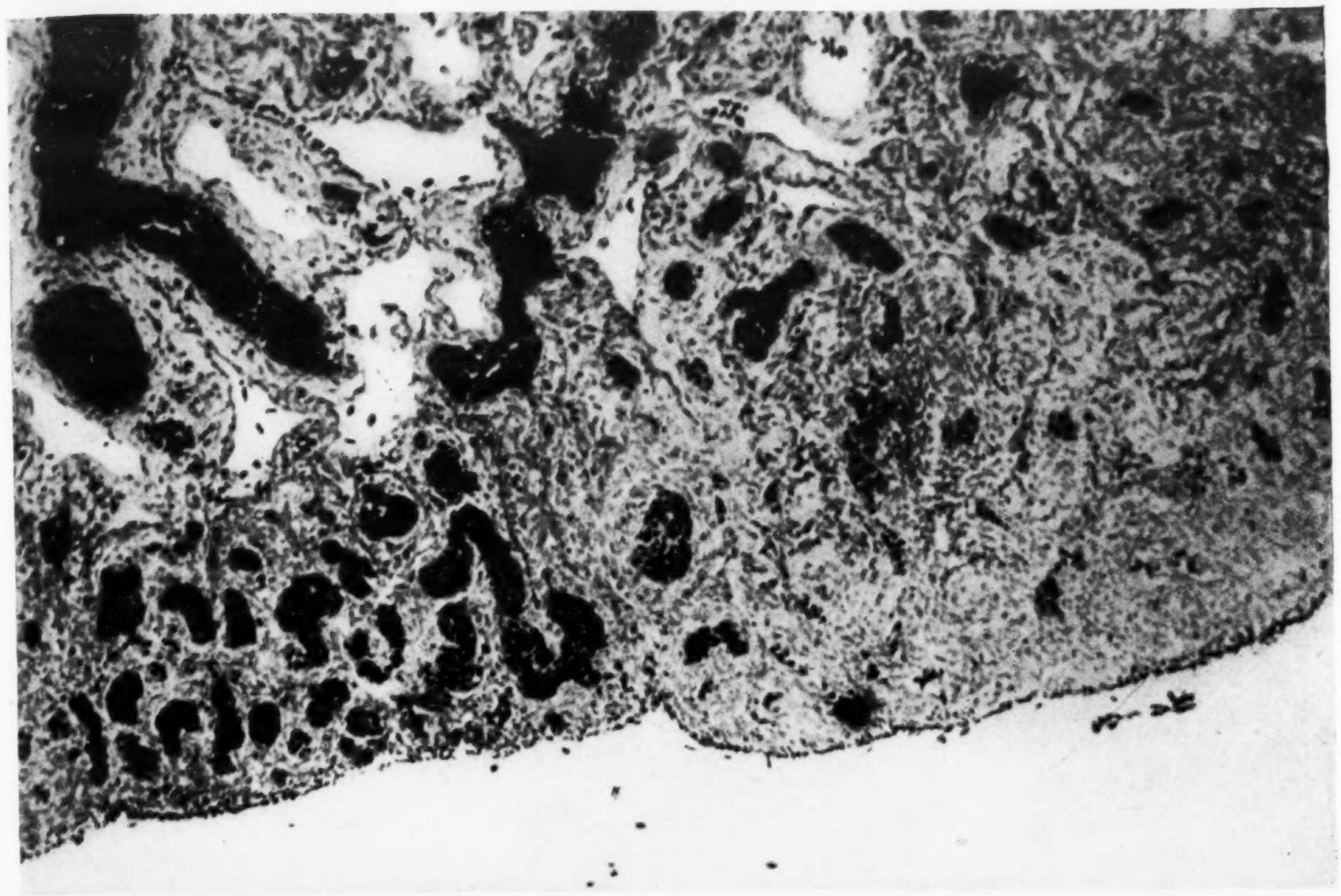


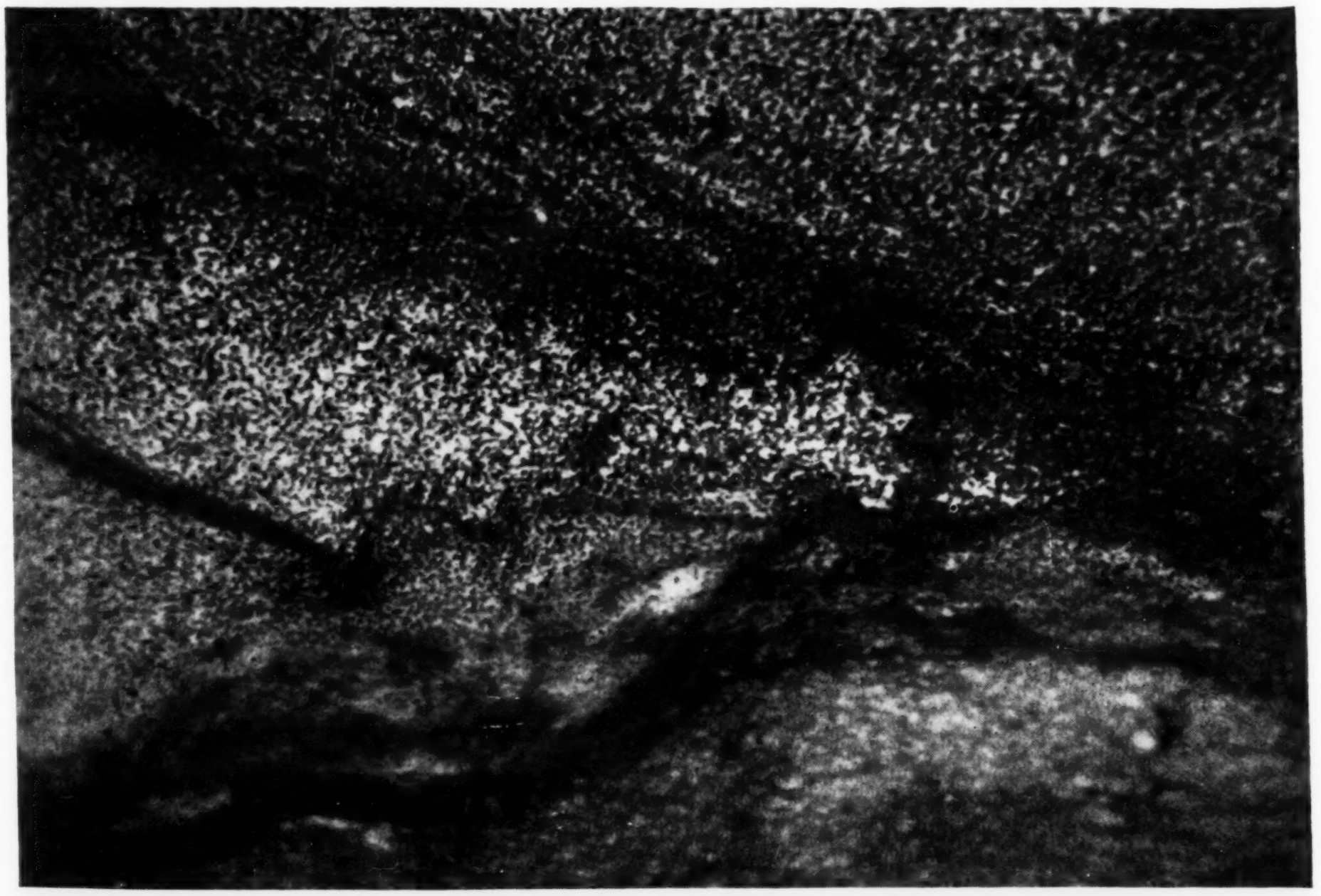
April 12, 1922

October 22, 1922

CHANGING FROM BLACK TO WHITE

FIGURE 3. The first unusual thing noticed about this hen was that she began to take on cock-like characteristics. The large comb is the most noticeable of them. She also began to crow. Then, every time she moulted some of her black feathers were replaced by lighter colored ones, and in less than twenty-one months she had become almost entirely white. Her adrenal glands were found to be atrophied, and it is possible that the changes in metabolism brought about by a lack of their secretions resulted in this change of color. In humans the rare and fatal "Addison's disease" is always accompanied by a diseased condition of the adrenals, and by a peculiar pigmentation of the skin.



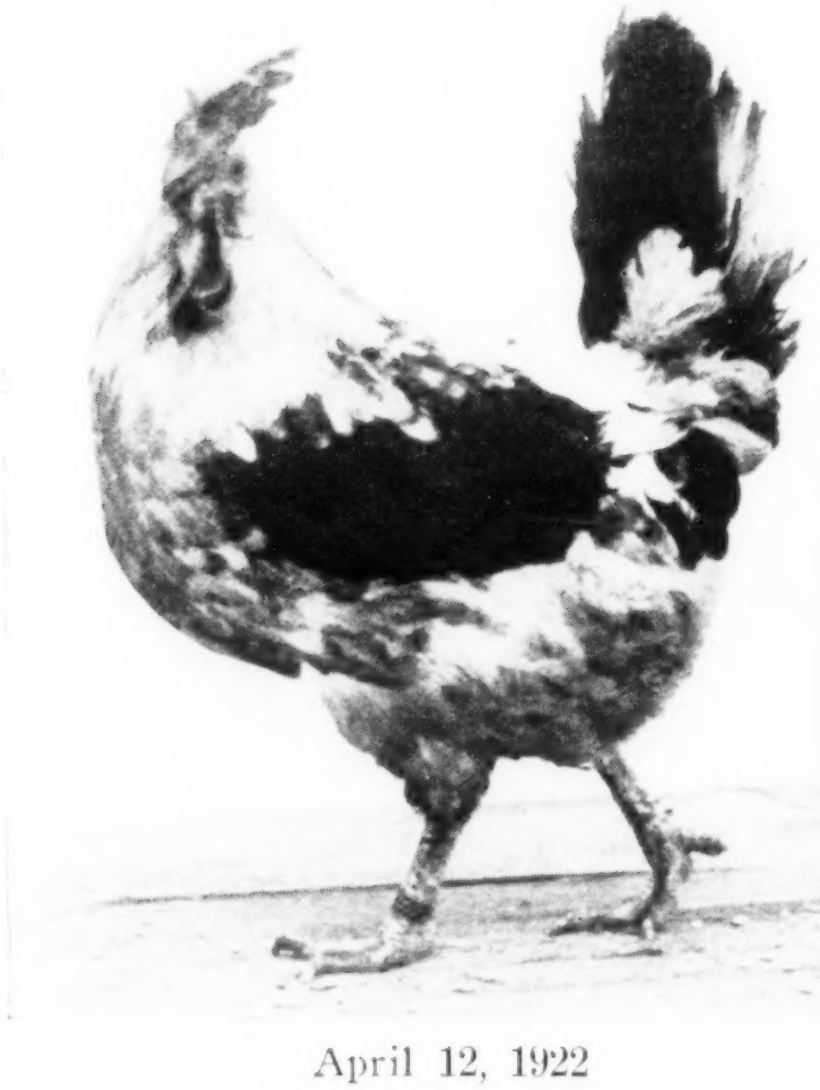


TWO SECTIONS THROUGH THE TUMOR

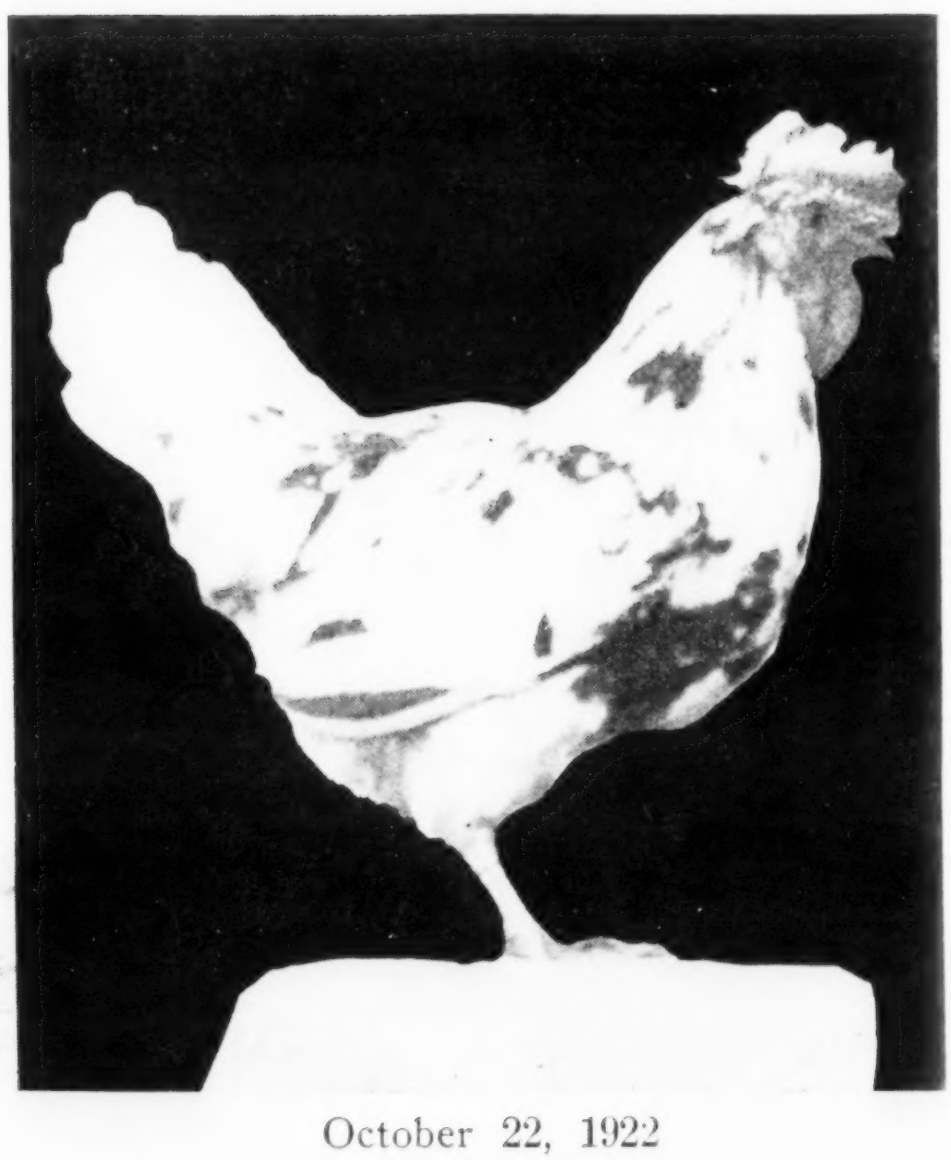
FIGURE 4. Above is a section through the ovarian part of the tumor, showing the entire absence of any follicular tissue. Below is a section through the blood clot. Nothing resembling normal ovarian cell structure is present. Apparently it was this degeneration of her ovary that caused the hen to take on cock-like characteristics.

January 21, 1921

September 15, 1921



April 12, 1922



October 22, 1922

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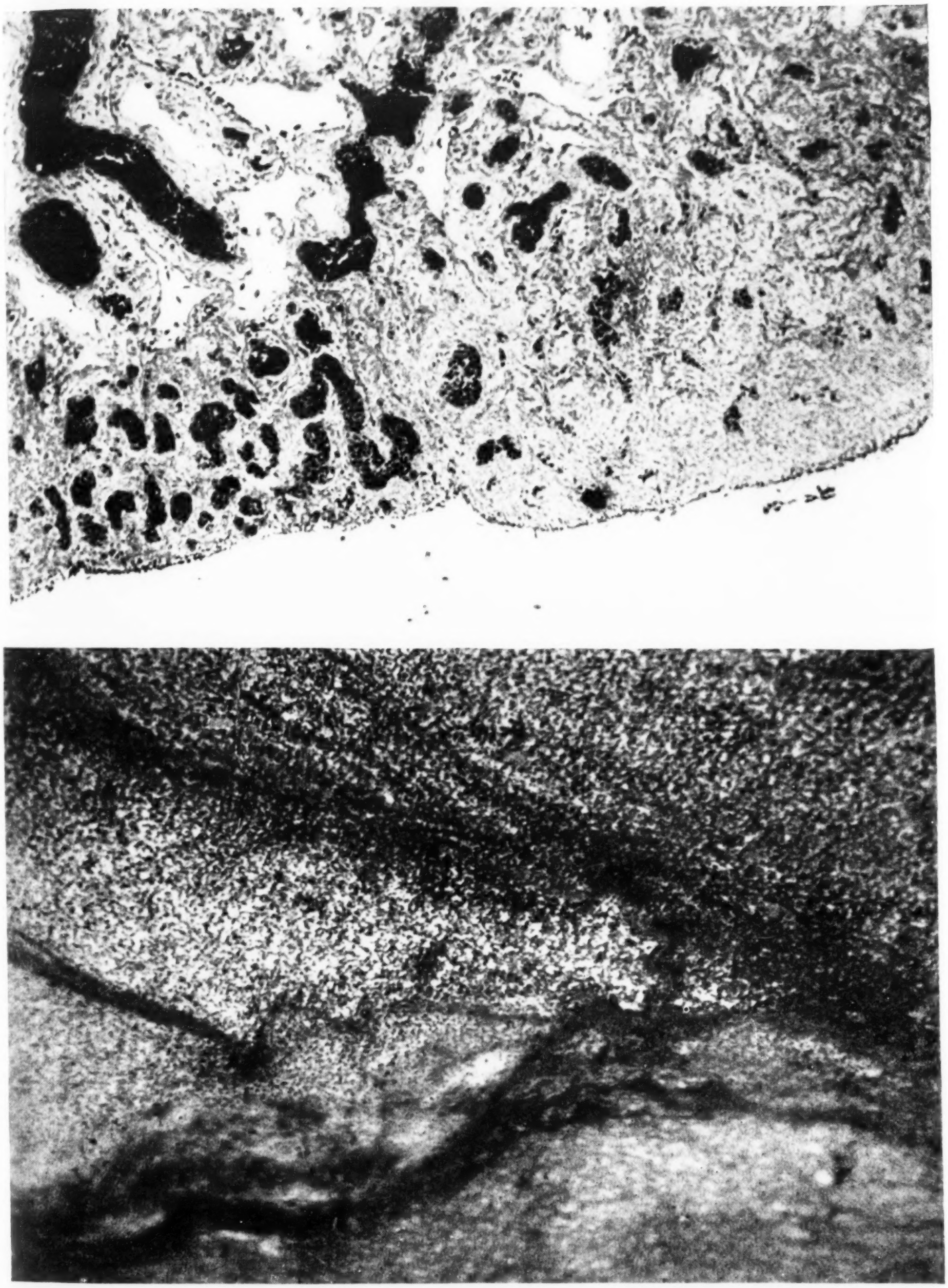

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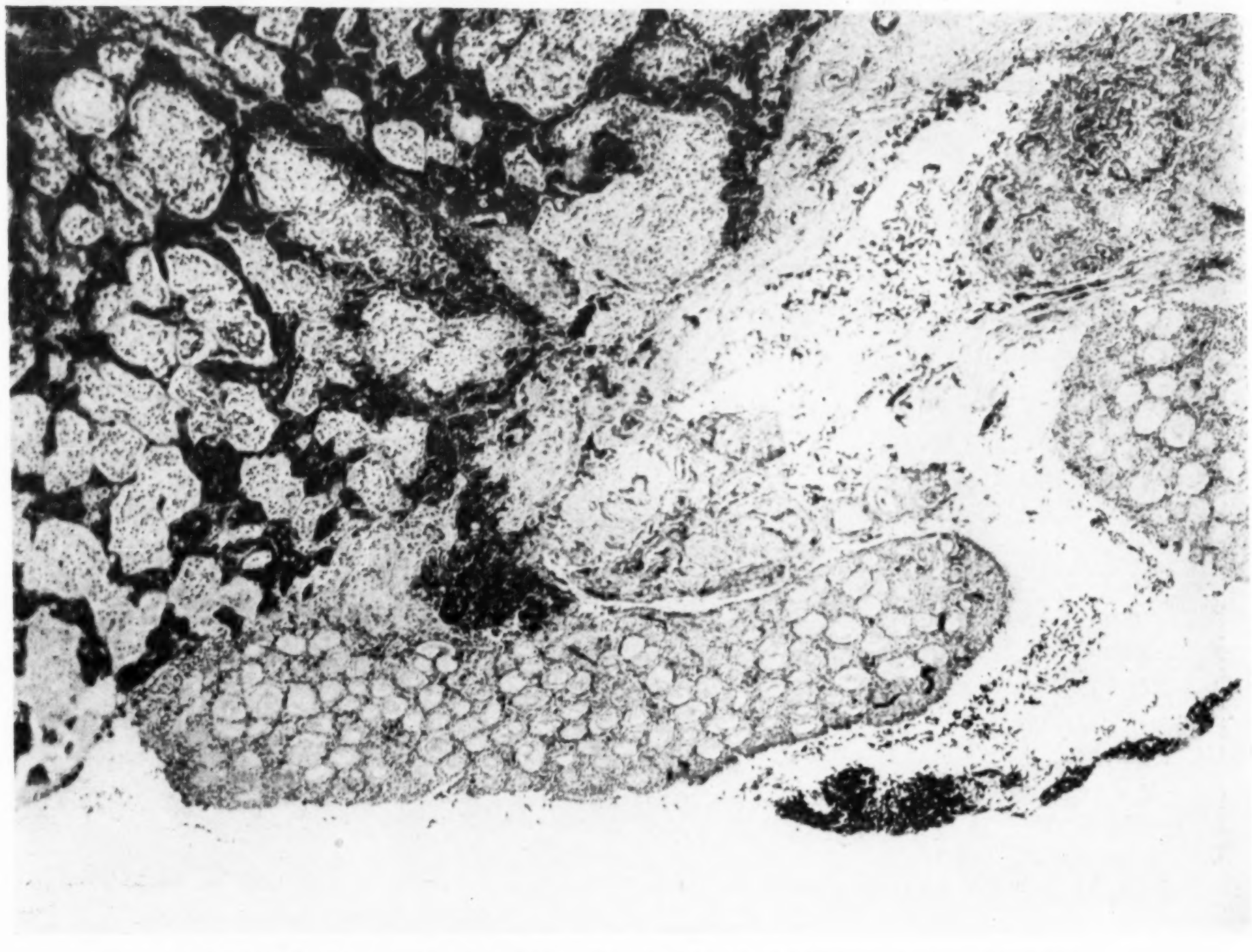


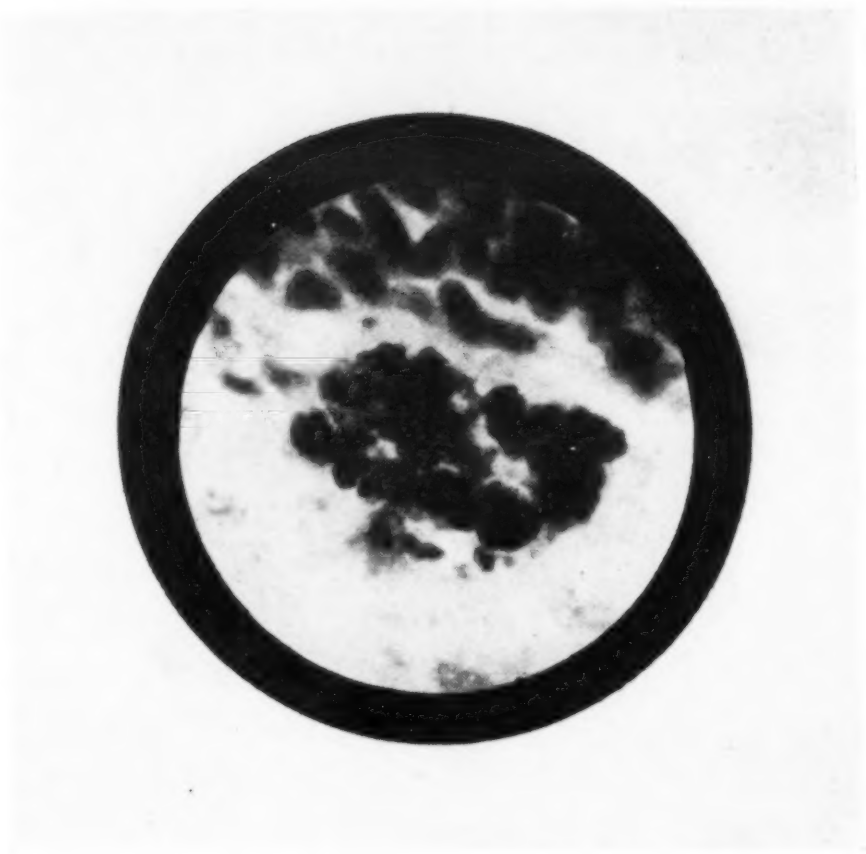
OVARY AND ADRENAL OF TWO-MONTHS-OLD CHICK

FIGURE 5. Showing the cellular continuity of the ovary and adrenal. In the hen they are histologically continuous, at least up to the time of laying. Consequently it is not remarkable that tumor growth affecting the ovary should involve the adrenal also.

of groups of cells most numerous in the proximal portion, but scattered throughout the gonad. In the region immediately adjacent to the non-ovarian part of the tumor these cells were extremely numerous and on section appeared as a continuous band. The luteal cells were everywhere most conspicuous, being without exception crowded with pigment granules which frequently obscured all cell structure. The rest of the tumor was composed entirely of laminated blood clot, fibrin and nucleated red corpuscles with no evidence of any structural tissue elements. The red blood corpuscles had undergone lysis.

Origin of Luteal Cells

The condition of the luteal cells is of interest in view of Morgan's hypothesis that it is this element of the ovary which is responsible for the henny feathering in birds. The histology of the luteal tissue has been studied by Pearl and Boring, and according to these authors it is first seen as islets of clear cells situated in the walls of the follicles and in the general stroma. In atretic and discharged follicles these multiply and the cells migrate into the cavity where they develop granules of lutear pigment in the cytoplasm. This account of the transition of the islets of clear cells into luteal tissue is not wholly convincing and on theoretical grounds would appear unlikely. The histogenisis of these islets of cells is being studied by Miss H. B. Fell, in this Department, and she finds that they arise in the distal portion of the sex cords, confirming the conclusions of Fikert and Nonicles. Owing to the enlargement of the oocytes and relatively slight increase in the stroma they finally come to lie among the former and are mostly incorporated in the follicles. It would seem more prob-



A MASS OF LUTEAR GRANULES

FIGURE 6. The exact function of the corpus luteum in birds is obscure. Some investigators believe it is responsible for the development of typically female plumage. However, this view would receive small support from the conditions found in this case, as the great amount of lutein present has not inhibited the development of male plumage and of other male characters.

able that the pigment-bearing cells of the fowl are formed, as in the Mammals, from the theca interna and are quite distinct from the islets. This conception requires that the secondary sexual characters might be controlled: (a) by the islets, or (b) by the pigment forming tissue. But as the latter tissue is not present in the young pullet, it would seem that the former are responsible for the development of the female type of plumage. Whichever view is taken, however, the histological study and the history of the fowl described in this paper point to the conclusion that ultimately, had she lived, she would have assumed male plumage.

From the examination of many other cases (as yet unpublished) of atrophic ovary in the hen, the conclusion has been arrived at that the formation of large quantities of pigment in the luteal cells is a sign of degeneration, the final stage of which is a structureless mass of lutear pigment lying among the stroma. If this is so, the cells in this case must have been almost functionless. On the other hand, if the small groups of clear cells are not homologous with the lutein-forming cells and are responsible for henny-feathering, then this fowl would undoubtedly have assumed the male type of plumage earlier since in this case these islets are entirely absent.

The tumor was firmly adherent to the dorsal body wall. After it had been carefully removed the adrenals were sought for. Neither could be found and from the relations of the tumor it was thought that these glands had become incorporated in the tumor. Nothing suggesting adrenal tissue, however, was identified on section of the tumor. It was hoped that it could be demonstrated that abnormality of the adrenal was associated in this case with the peculiar change in the pigmentation of the plumage. It is known that abnormality of the adrenal in the human is often associated with abnormality in pigmentation, as in Addison's disease. Save that neither adrenal could be found, even after the most careful search, nothing more can be said. It is possible that the progressive destruction of the adrenal was indeed responsible for the gradual change from black to white and that the complete destruction of these glands resulted in the death of the bird.

Continuity of Adrenal and Ovary

It has long been known that there is an intimate relation between the cortex of the adrenal and the gonad in the earlier stages of development. Microscopic examination, however, has shown that the ovarian and cortical tissues in the fowl are closely adherent and in fact are histologically continuous locally not only in the embryo but at least up to the time of laying. No previous reference to this point has been encountered and so this opportunity is taken to place the observation on record. Under these circumstances it is not remarkable that tumor-growth of the ovary should involve the adrenal.

SCIENCE IN THE SCHOOL

A Review

THE TEACHING OF GENERAL SCIENCE by W. L. EIKENBERRY, Associate Professor of General Science, University of Kansas. The University of Chicago Press, xiii+169 pp. 1922. Price $2.00 net.

As new subjects, particularly new sciences, develop there is a tendency to incorporate them in some form in secondary school curricula, either on the plea that since many of the students go no further this will be their only chance for an acquaintance with these subjects, or on the theory that being introductory these courses will stimulate a desire for further knowledge in the same fields. Courses in special sciences have however, been severely criticized on one ground or another, and in recent years there has been a tendency to bring in courses of a more general nature. Thus a few years ago Nature Study, so-called, was all the vogue, and more recently this has been evolved into what is currently called General Science. Professor Eikenberry's book is a critical consideration of science teaching and its objectives and an exposition of the methods of general science. General Science, as he visions it, has a difficult road to follow, being liable on the one hand to become merely an elementary treatment of one or two general sciences and on the other of being simply a smattering of a lot of things from several sciences, without a definite goal and carrying the danger of dulling the student's desire for pursuing the subjects further. The solution is believed to lie in the organization of the General Science course around things which pertain to the student's everyday life and interests. "General Science is built up largely with materials which have interest because of utilitarian and socializing values." It seeks to supply a common foundation. "It assumes that it is not possible to rise into the higher intellectual levels during the first year, and it therefore contents itself with attempting to organize the immediate and familiar environment of the pupil in as useful fashion as possible. It may go farther and indicate in which directions the principal fields of science lie, but it leaves for later science study the more philosophical organization of those fields."

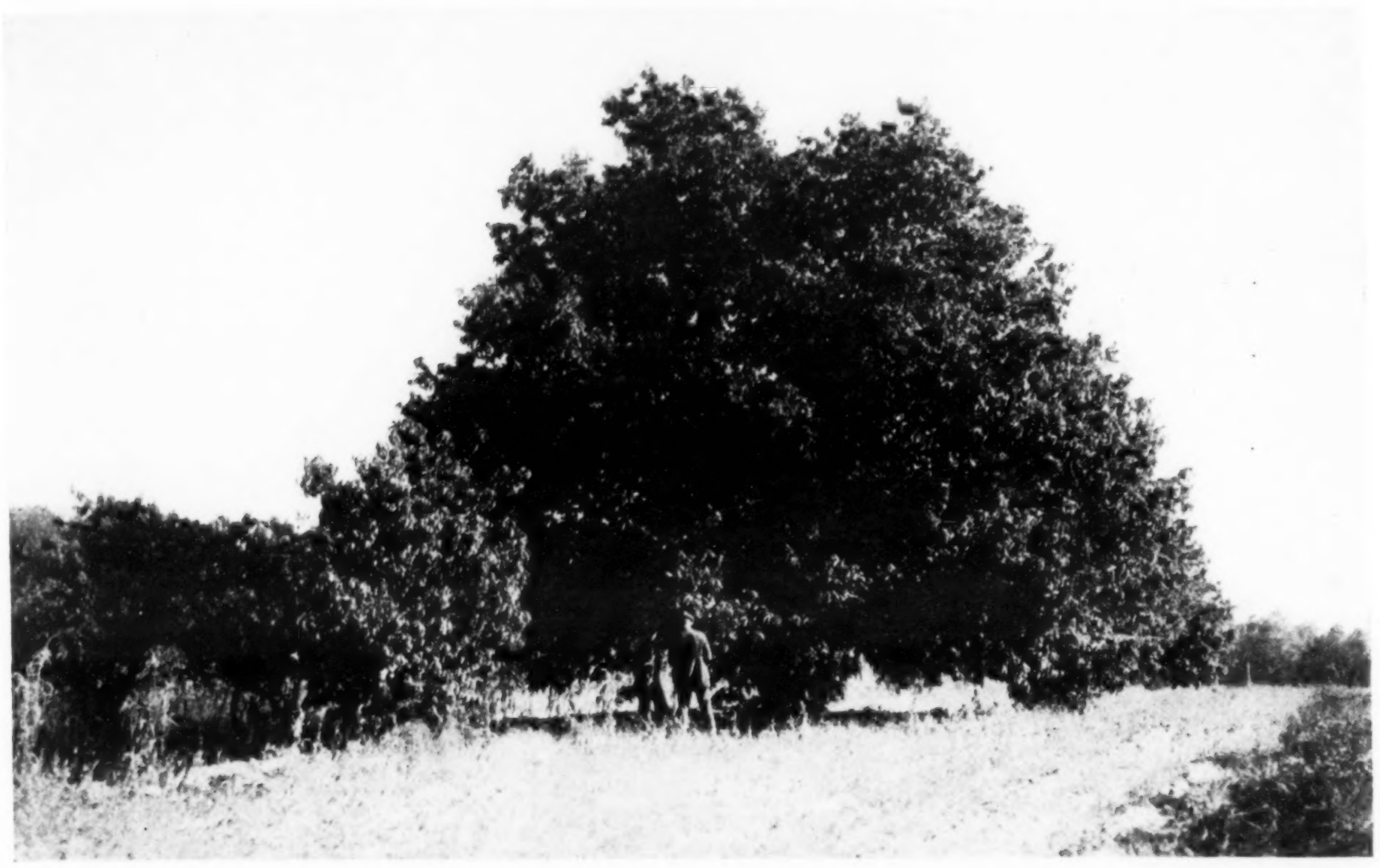
While heredity and eugenics are not specifically discussed as material for a course in general science, it would seem that they both, and particularly certain phases of eugenics, offer subject matter of intimate and vital interest to the pupil and with distinctive social-civic value. On the other hand, an attempt to teach to high school students the complicated principles and relationships of Mendelism would, in the opinion of the reviewer, be a great mistake, and this view would seem to be shared by the author (p. 61.).

One is inclined to conclude that in its present development at any rate, perhaps even more than in one of the old well-established special sciences, the real value and success of a course in General Science will depend on the broad training, sympathy and ability of the teacher.

L. J. C.

AN ORCHARD OF CHESTNUT HYBRIDS[1]

J. A. Detlefsen and W. A. Ruth
College of Agriculture, University of Illinois, Urbana, Illinois



A HYBRID BETWEEN JAPANESE AND AMERICAN CHESTNUTS

Figure 7. In 1898 Mr. Endicott was successful in obtaining five chestnuts by crossing the Japanese and American species. From these he raised three trees, of which this is the largest. The trees were remarkably vigorous and fruited precociously, one at seventeen months, one at four years, and the other at five years of age. The Japanese chestnut does not usually begin to bear until it is six years old, the American at about twelve years. See text, p. 306.

WITH the rapid disappearance from the American continent of the native chestnut tree through the ravages of the chestnut bark disease, there has come the demand for a substitute. The discovery in China of a species of chestnut resistant to this disease, and the ease with which hybrids between the different species can be produced has led to the hope that hybrid chestnut trees may take the place of the native American species. Mr. J. F. Rock, the agricultural explorer, is now in China collecting all the species of chestnuts he can find there in order that this breeding material may be placed in the hands of American plantsmen, to be used for crossing with the native species to develop the new hybrid chestnut. This article, which calls attention to what a single plant breeder was able to do with the material at his disposal, has a direct bearing on this important problem.

In many parts of the Appalachian Mountains the chestnut is, or was, the most abundant and important forest tree. In some places it made up fifty per cent of the hardwood timber; and it has been estimated to have constituted at least ten per cent of all the hardwood forests in the eastern United States, before the ravages of the bark disease began. Unless it is possible to develop a resistant hybrid that can be easily propagated, one of our most beautiful and useful trees is doomed to disappear from American forests.

Editor.

[1] Paper No. 19 from the Genetics Laboratory, College of Agriculture, University of Illinois. The writers are indebted to Professor J. C. Blair, who furnished some of the facts relating to the early history of this orchard and also made possible an opportunity to visit it.

OCCASIONALLY on some remote farm or ranch a genuine Mendelian experiment of great interest and significance is performed and lies entirely buried until a fortunate accident brings it to light. Our former Colleague, Professor E. W. Bailey, kindly drew our attention to such a case—an orchard of unique chestnut species hybrids. He later placed at our disposal some of the materials which he had collected. We are presenting some of the more obvious and striking facts for the sake of their scientific, historic and practical value. The case is especially valuable, since it affords an excellent example of genetic laws in tree hybridization. In 1899 Mr. George W. Endicott, of Villa Ridge, Illinois, crossed the Japanese chestnut, *Castanea japonica* (probably variety Coe, but known locally as Japan Giant) with pollen from the American sweet (*C. americana*). The mere cross in itself was hardly remarkable, inasmuch as several chestnut species crosses had been made before. But Mr. Endicott raised an orchard of about 175 second generation hybrids which are particularly interesting to the geneticist, since all of these trees are now twelve to fifteen years old and are bearing.

Introduction of European and Japanese Species

Edible chestnuts are sometimes divided into three large groups (or species), the American, European, and the Japanese. All three are now grown in this country, but only the first is indigenous. The history of the earliest introduction of the European species is rather obscure, but the general dissemination of this chestnut certainly dates back to about 1800,[2] when Eleuthere Irenee du Pont de Nemours planted a number of French chestnuts in his garden near Wilmington, Deleware, where he had settled after emigrating with his family to America in 1799. The descendants of these trees or their scions have been extensively propagated in this general region of the United States. However, there must have been isolated cases of importation before this time, because there is an obscure record[3] that Thomas Jefferson grafted the French marron to the American sweet in 1773, at his home in Monticello, Virginia. The importation of the Japanese species was much more recent and was the direct result of attempts to introduce this type on a commercial basis. The S. B. Parsons Co. of Flushing, N. Y., in 1876; William Parry, of Parry, N. J., in 1882; and Luther Burbank, of Santa Rosa, Cal., in 1886, were among the earliest nurserymen and horticulturists to attempt this importation and introduction. The last of these importers planted over 10,000 Japanese seedlings and selected three as desirable—the Coe, the Hale, and the McFarland. Mr. Burbank had several hundred hybrid chestnuts just beginning to bear about 1899—from crosses involving the chinquapin, the Japanese, European, and Chinese chestnuts, and other types, according to Powell's[2] report. Van Fleet[4] produced hybrids involving European, Asiatic and American types between 1894 and 1911. We have, however, little or no information on the segregation in the second hybrid generation in either of these cases. Mr. Endicott made his first successful cross about this time, i. e., in 1899.

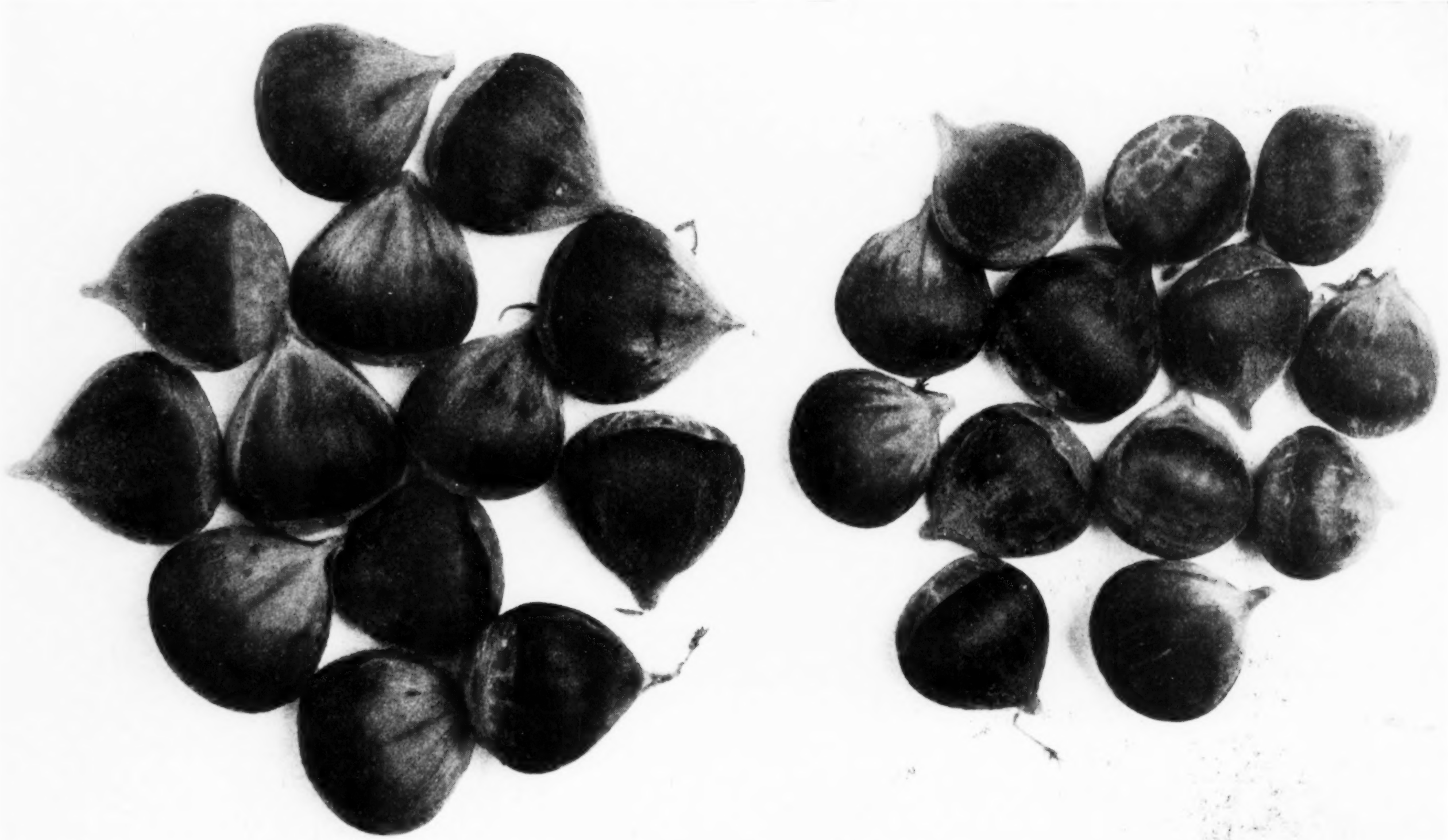
Mr. Endicott's Crosses

Mr. Endicott was much interested in hybridization and recognized its possibilties for the chestnut, since he had perfected the Endicott plum and other fruits. Practically throughout his whole life he was interested in

[2] Powell, G. H. *11th Annual Report*, Delaware Agricultural Experiment Station. 1900.
[3] Bailey, L. H. *Standard Cyclopedia of Horticulture*, MacMillan Co., N. Y. Vol. II, p. 742. 1914.
[4] Van Fleet, W. *Journal of Heredity*, Vol. V, No. 1, pp. 19-24. 1914.

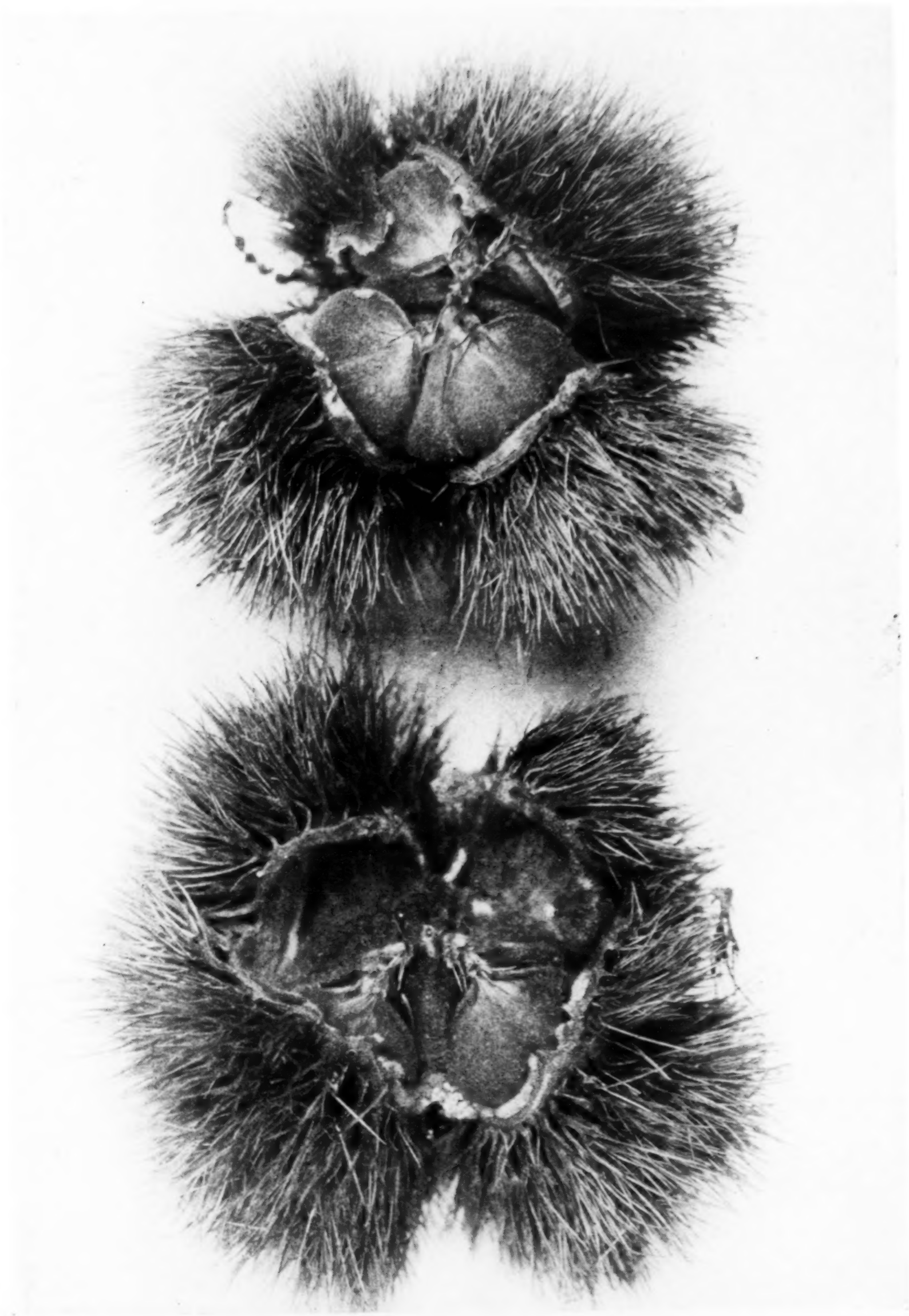
LARGEST AND SMALLEST TREES OF THE SECOND GENERATION

FIGURE 8. The results of Mr. Endicott's first crosses were so encouraging that he raised a second generation from the Boone, which he considered the most promising of his three original hybrid trees. As a means of increasing his stock of superior trees this effort was a failure, for the greatest variation was found in the second generation trees. Some were vigorous growers while others were of dwarf habit. Soil conditions may have been a factor in producing the contrast in size shown above, but it is certain that the hereditary constitution of the two trees had something to do with it, as the smaller one is perfectly healthy and bears heavily.



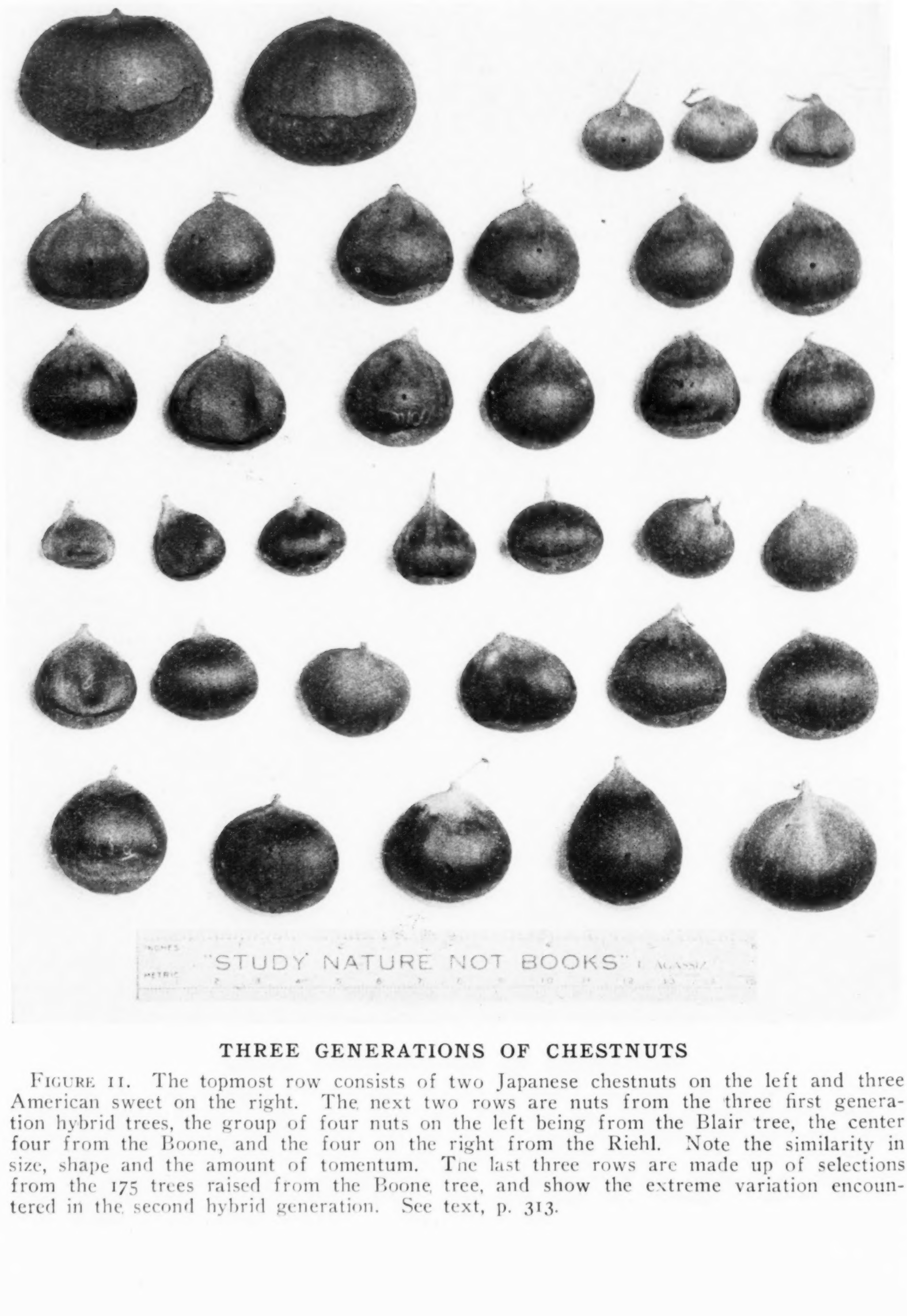
NUTS FROM TWO OF THE SECOND GENERATION TREES

FIGURE 9. All nuts from the same tree are remarkably similar, but those from different trees vary greatly in size and shape and in the amount of tomentum. Some trees have several nuts to the burr, others only one. In some cases the nuts are free in the burr, like the Japanese, while other trees have nuts as firmly attached to the burr as the American sweet.



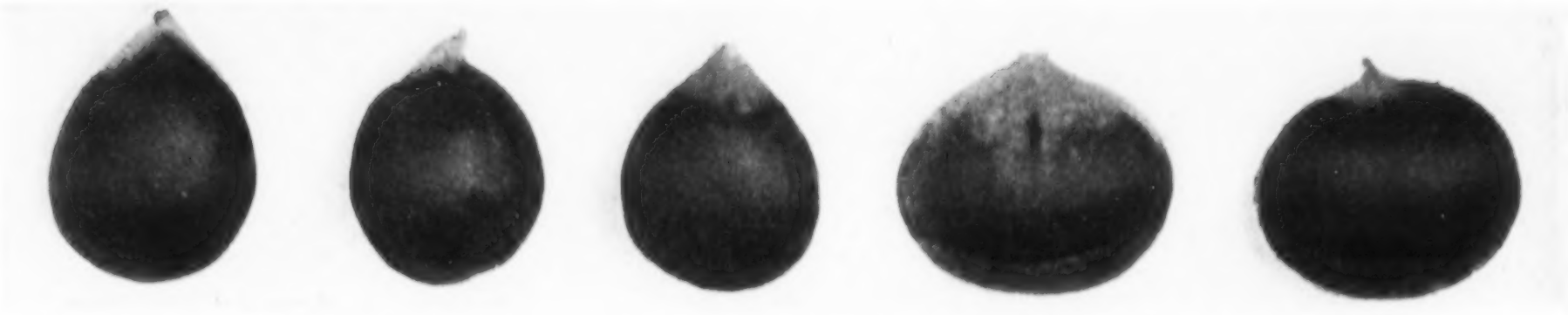
MANY NUTS TO THE BURR

FIGURE 10. Some of the segregates gave as many as seven or eight nuts to the burr, whereas the Japanese parent has one and the American parent three. The nuts from such burrs are too small and misshapen to be of any great value.



THREE GENERATIONS OF CHESTNUTS

FIGURE 11. The topmost row consists of two Japanese chestnuts on the left and three American sweet on the right. The next two rows are nuts from the three first generation hybrid trees, the group of four nuts on the left being from the Blair tree, the center four from the Boone, and the four on the right from the Riehl. Note the similarity in size, shape and the amount of tomentum. The last three rows are made up of selections from the 175 trees raised from the Boone tree, and show the extreme variation encountered in the second hybrid generation. See text, p. 313.



NUTS FROM THE SECOND GENERATION TREES

FIGURE 12. These nuts show further variations in the second generation. The three on the left are acorn-shaped, being from trees that produced but a single nut in a burr. The two on the right are nearly the same size, but they are flat on one side and the amount of tomentum is very much less on one than on the other. See text, p. 314.

plant improvement. Born in 1839, he was 60 years old when he made his first successful chestnut species cross. He was 70 years old when he planted a large orchard of over 150 F_2 trees. He died in 1914 without seeing the final results of the second generation of his interesting cross. In choosing the Japanese and the American sweet for hybridization, Mr. Endicott probably had in mind the combination of certain very desirable characters from each parent. He had a large number of American sweet chestnuts growing on his land, but he wished to improve them, for he recognized their shortcomings as well as their desirable qualities. The Japanese type has the advantages of a large nut lying free in a relatively smaller burr, is rather resistant to weevils, blooms and matures early, and has a nut with more attractive color and less tomentum; while the American type has three small nuts very tight in the burr, is susceptible to weevils, blooms and matures later, and has nuts of poor color and heavy tomentum. The American sweet, however, has nuts of fine quality with a thin skin, grows vigorously and produces a large tree, whereas the Japanese has poorer quality (at least in many cases), a thick skin, and produces a low bushy tree of delicate growth. A combination of the desirable features from these two sources naturally recommended itself to Mr. Endicott and therefore he attempted to make the cross.

He seemed to have some difficulty in the routine technique, for the Japanese and the American sweet differed in time of blooming. Eventually he produced five hybrid seeds from which he raised three trees, naming them the Blair, the Boone, and the Riehl. As we might expect, the three trees of the first generation were not all exactly alike, for the parents (at least the Japanese) were more or less heterozygous. As a matter of fact, it is surprising that the three trees were as nearly similar as we found them. Like the American sweet, the Blair and Boone produced three nuts to the burr, while the Riehl produced a single perfect nut with an aborted nut on each side like the Japanese parent. All three first generation hybrids produced nuts free in the burr like the Japanese parent. All of these trees showed tremendous vigor (Fig. 7.) The largest, the Riehl, had a spread of forty-five feet when twenty years old. The Blair and Riehl began to bear at four and five years, respectively, while the Boone bore its first nuts at seventeen months. When we compare this with the Japanese and the American parents, which begin to bear at about six and twelve years, respectively, we gain some idea of the precocity which accompanied the hybrid condition. Van Fleet[4] reports similar vigor in crossing Asiatic and European chestnuts with the chinquapin and the American sweet—the Japanese hybrids being again the most precocious. These hybrids were likewise heavy bearers, the Boone producing as much as six bushels in

A PARENT TYPE AND TWO SECOND GENERATION SEGREGATES

FIGURE 13. The American sweet on the left is almost indistinguishable from the adjoining burr, which is a second generation segregate. The burr on the right is also from a second generation tree, but it almost exactly resembles its Japanese ancestor. Only one nut has developed and the two aborted side nuts, or "side blasts," offer no hindrance to the formation of a rounded, acorn-like nut. It is interesting to note that one desirable quality has been passed on by the Japanese parent to nearly all of its offspring. This is resistance to attacks by weevils, whose love for the American sweet has given rise to that ancient "chestnut," "what is worse than finding a worm in a chestnut?" With one exception all of the trees of the Japanese-American cross are free from weevils. Year after year, this tree, although surrounded by an orchard of trees untouched by weevils, is badly infested and harbors a large crop of them. See text, p. 314.

a single season. The vigorous growth of the hybrids is shown by their having a spread of over forty-five feet, while the American sweet and the Japanese parents measured about thirty and sixteen feet, respectively.

The Second Generation

The first generation hybrids, particularly the Boone with its vigorous growth, early maturity, and with an abundance of nuts of excellent quality and large size aroused Mr. Endicott's interest to such an extent that he planted over 175 seedlings from this particular hybrid tree. A first planting of twenty-five second generation seedlings was made in 1906, and a second planting of over 150 was made in 1909. All of these are undoubtedly genuine second generation hybrids, because the three first generation trees were quite isolated in a field almost a mile from the nearest American sweet. While all the second generation hybrids were grown from the Boone nuts, it is of course possible that the male parent was occasionally either Blair or Riehl, since the three trees were planted in a row and spaced about one hundred yards apart. This does not vitiate our Mendelian experiment, for in any event the second generation trees came from the first generation mated interse, and probably all or nearly all of them actually came from the self-fertilized Boone hybrid.

In perpetuating the Boone chestnut, by growing a second generation, Mr. Endicott had hoped to see a fairly constant repetition of the excellent qualities of his first three hybrids, namely three large nuts of good color and quality with little tomentum, lying free in the burr, and a vigorous heavy yielding tree. Of course, he was doomed to disappointment in this respect, because the most pronounced segregation was inevitably predetermined. The second generation trees were very uneven in growth and size. The smallest was hardly more than eight feet high, while the largest was about twenty feet high, when they both were fourteen years old (Fig. 8). None of the trees showed the extreme vigor or precocity or heavy-bearing qualities characteristic of the first generation. While the original Boone tree bore its first nuts at seventeen months, the second generation Boone trees were from five to nine years old before bearing; this range almost covers the difference between the original Japanese and American sweet parents. The time of ripening also showed wide variation, since it overlapped both parents. In 1920, for example, the second generation trees ripened their nuts from the first week in September through the middle of October.

In size of nuts the trees showed unmistakable segregation. The nuts of the original hybrid were intermediate between both parents, but these trees gave a greatly increased range of sizes (Fig. 11). Some were as small as the American sweet, and all grades were found up to forms larger than the first generation Boone and almost as large as the Japanese. The amount of tomentum was intermediate in the first generation, and showed a great range in the second. Almost any size nut could be found with any degree of tomentum. The first two and last two F^2 nuts in Fig. 11 illustrate this point. While the nuts on different trees showed a great range of variation in size, form and tomentum, the nuts on any individual tree were remarkably uniform. Figure 9 shows two groups of these second generation nuts. Each group, coming from a single tree, is uniform within itself, but one group gives consistently larger nuts, with slightly more tomentum.

Most of the trees gave three nuts to a burr, but some gave only one nut with two aborted nuts like the Japanese parent (Fig. 13), and others gave as many as eight nuts in a burr (Fig. 10). When a tree produced singles these were often ovoid or acorn-shaped (Fig. 12). While all three of the original hybrid trees pro-

duced nuts free in the burr, segregates appeared in the second generation with nuts just as firm as those of the American sweet. Probably fifty per cent. of the trees produced free nuts, while six per cent. were very tight, the remainder being intermediate. Segregates closely resembling the American sweet were found, both in size, shape, number of nuts and character of burr (Fig. 13).

Resistance to Weevils

For many years all the trees of both generations with one exception have been resistant to weevils like the Japanese parent. The single exceptional tree has always given nuts badly infected with weevils, while all the rest of the trees in the orchard have been immune.

The character of the burr also showed much variability in the second generation in respect to thickness, length of spines and the like. The spines of some burrs were relatively soft and easily handled, while others were extremely rigid. All gradations between these extremes were found.

When it was found that the second hybrid generation was so exceedingly variable and not as valuable as the original hybrid, an attempt was made to propagate the parent vegetatively by grafts and by top working the worthless second generation seedlings with original Boone wood. Mr. Endicott was accomplished in the art, but never had much success in the use of F_1 wood on F_2 trees. In many trials (over 400) made by Mr. Endicott and Mr. E. A. Riehl (an expert nurseryman) about three per cent. of the attempts to bud or graft were successful. Possibly some obscure anatomical or physiological peculiarities of the wood of the first generation make a union with other woods difficult, even with its own seedlings.

All of these striking variations in the second generation trees bear the earmarks of multiple factor segregation and recombination. There are many other characters involved besides these more patent examples which we have chosen to record. No doubt intricate structural and physiological characters are also included. The orchard might prove to be a storehouse of promising material for anyone inclined to pursue investigations in this direction.

How Relatives Originate

THE EVOLUTION OF KINSHIP, AN AFRICAN STUDY, by E. SIDNEY HARTLAND, LL. DL., F. S. A. The Frazer Lecture, 1922. Pp. 31; price 70c. Oxford University Press, American Branch, New York, 1922.

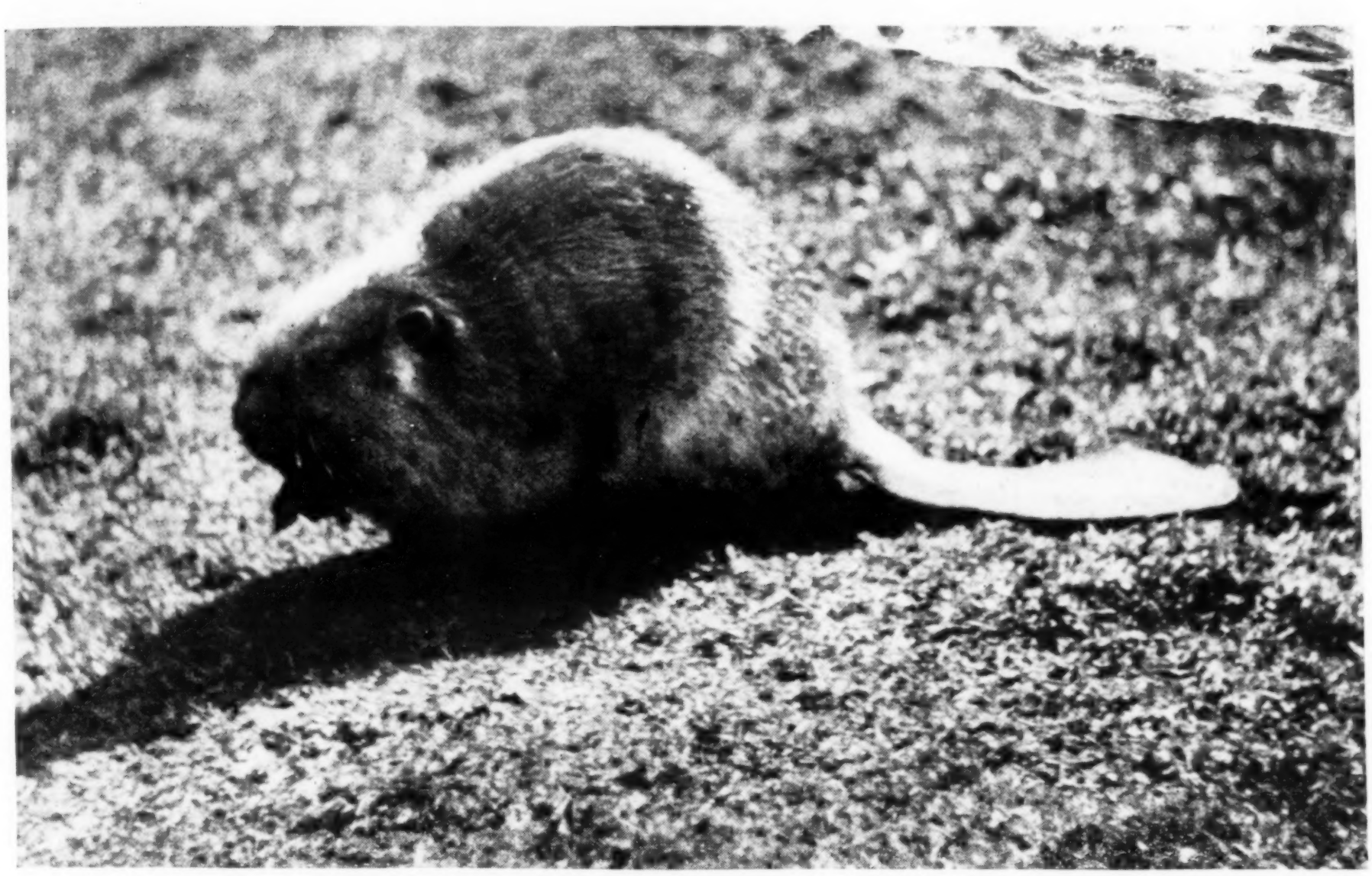
Drawing his illustrations mainly from some of the Bantu tribes, which inhabit Africa from the equator to the south coast, Dr. Hartland sketches the primitive state in which descent is traced through the mother, followed by the slightly more advanced stage in which it is traced through the father. In both instances the relationships are thought of by the individuals concerned as social rather than physiological. The two systems of descent are in many tribes still competing for supremacy, which results in some involved situations that are interestingly set forth.

—*P. P.*

BEAVER FARMING

VERNON BAILEY

Biological Survey, U. S. Department of Agriculture



A CAPTIVE BEAVER

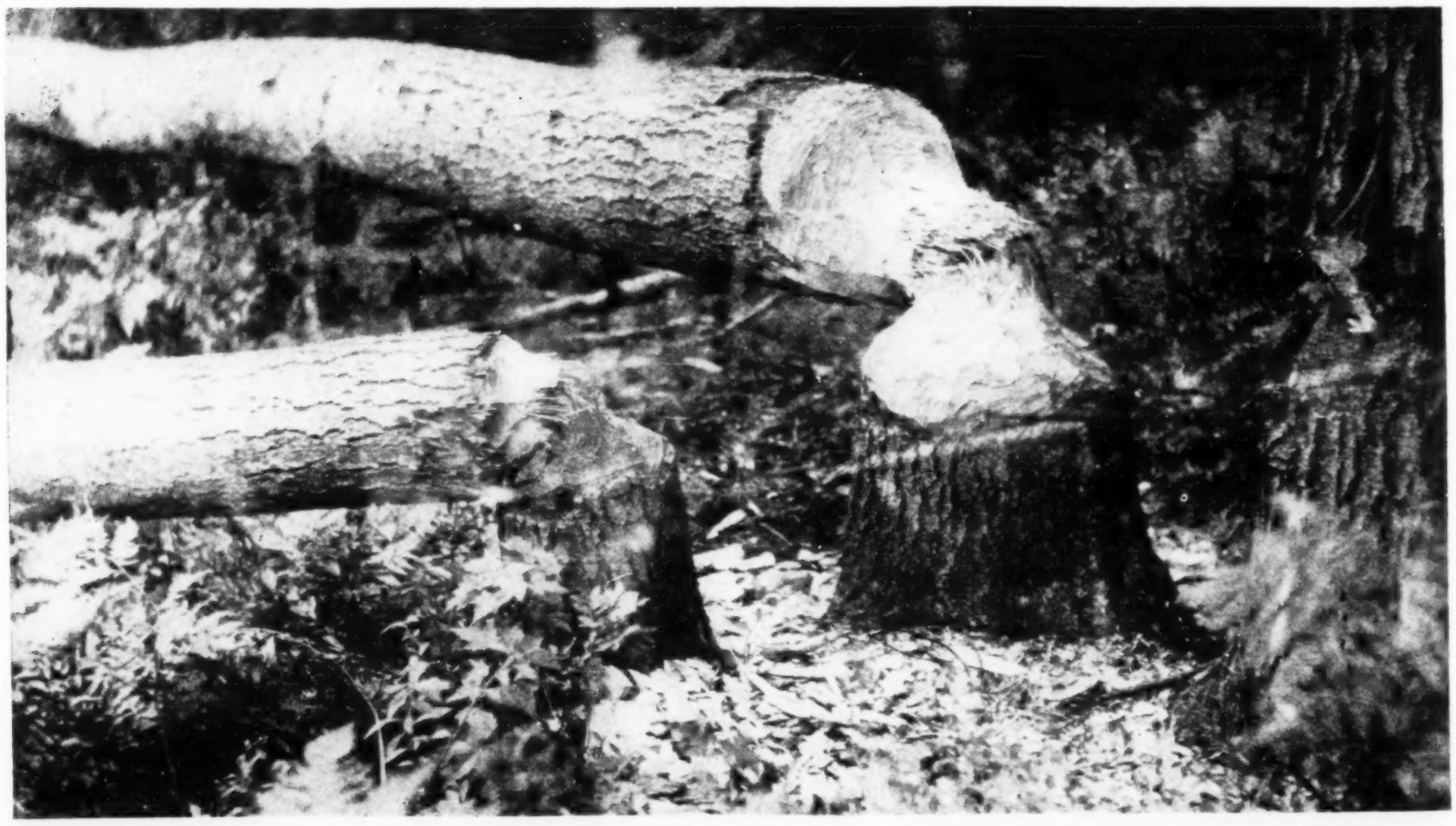
FIGURE 14. This old gentleman was caught in a pitfall for study. He was quite gentle and easy to handle from the first. Beaver farming is an industry still in the experimental stage, but offering great possibilities. Land not suited for any other purpose can be used, and deforested areas could be made to produce valuable crops of beaver fur while being reforested. Photograph from U. S. Biological Survey.

A NEW line of fur farming promises an important addition to our rapidly diminishing supply of the warmest clothing known. *Beaver Habits, Beaver Control, and Possibilities in Beaver Farming* is the title of a bulletin just published by the Department of Agriculture, in which it is shown that while the actual raising of beavers on a business basis is still in the experimental stage, enough has been done to show that there are no insurmountable obstacles to be overcome. Beavers are easily tamed, and become very gentle and affectionate pets; they breed in captivity, are contented as long as there is a satisfactory food supply, and are easily fenced and kept within bounds. Their favorite food consists of the bark of small aspens, cottonwoods, willows, pin cherries, and other bushes and trees of little or no value for timber purposes, and they thrive and produce the best fur in regions too cold and rough for successful agriculture.

Beavers begin to breed when only a year old, and when two years old are practically fully developed. Four is the usual number of young in a litter, but there are records of six and a few of eight. While reproduction is less rapid than in most rodents, the beavers have few enemies except man and are

A BEAVER LODGE

FIGURE 15. Beaver houses are made of mud and sticks and their construction represents no mean feat of strength and skill for the little animals. The branches of a winter food-cache of sunken wood are visible on the left, the buds and bark being the parts that are relished. Photograph from U. S. Biological Survey.



BEAVER WOODCRAFT

FIGURE 16. Yellow poplars cut by beavers for food and building material. Aspens, poplars, and cottonwoods are favorite food and easily cut. Canals are dug in which to float the trees to the pond. Photograph from U. S. Biological Survey.

BREAKFAST TIME

FIGURE 17. Baby beavers getting their meal from ordinary baby bottles, which they would call for vociferously every three hours. Four is the usual number of young born in a litter, but cases are on record of six or even eight being born at one time. Selection of more prolific strains would be one of the qualities the beaver farmer could work for. Photograph from U. S. Biological Survey.

WORK OF THE BEAVERS

FIGURE 18. This dam across a creek in the Adirondacks holds water about four feet above the original level. Beaver activities sometimes bring them into conflict with man, as their dams have caused flooding of fields and railroad tracks. Photograph from U. S. Biological Survey.

extremely healthy and hardy, so that actual increase under favorable circumstances is rapid.

The key to success in beaver culture, however, is going to be selection and improvement of breeding stock. The darkest and handsomest deep ebony-brown beaver fur is found along the south shore of Lake Superior, where skins are worth two or three times as much as those of the paler varieties from the Western and Southwestern States. Skins from this region have sold for as high as $50 in the open market, and choice, bred-up, and perfectly prime skins should be worth considerably more than trapper's prices. Very long and almost black beaver fur comes nearer in general appearance to sea otter fur, the most valuable fur in the world, than any other fur known. Moreover, if well kept and properly combed, it is very durable and warm, as well as beautiful.

Fortunately there is an ample supply of choice beavers obtainable, so that no one will be able to corner a market on the best breeding stock and run prices to an unreasonable figure. The industry of raising beaver fur should be well adapted to large, as well as small tracts of suitable country, and its greatest value promises to be in the development of immense areas of north country now considered almost worthless. Burnt-over and cut-over timber lands usually carry the best growth for beaver food, and while paying a profit in fur these areas can be slowly reforested with valuable timber.

THE USE AND VALUE OF BACK-CROSSES IN SMALL-GRAIN BREEDING

HARRY V. HARLAN AND MERRITT N. POPE

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BACK-CROSSES have long been used in animal breeding to fix desired characters in cattle, horses, or other live stock. Despite any bad effects of inbreeding, back-crossing has been one of the best methods of retaining desired variations of conformation or other intangible complex characters.

So far as the writers know, back-crosses have not been used in small grains to secure definite types in the progeny. They have been used to study inheritance and incidentally have entered into the complex hybrids made more frequently by early plant breeders than at present. They seem to have been largely if not entirely neglected in any definite breeding programs to produce progeny of specific types, in spite of the fact that most small grains are self-fertilized and hence are immune to the evil effects of inbreeding. On the other hand there has been a nearly universal assumption that desired types are to be selected from the F_2 progeny of matings of suitable parents. Recently there has been a widespread feeling that large numbers should be used.

The writers feel that there is an important place for back-crosses in small grain breeding that is not now fully appreciated. It must be acknowledged at the same time that the barley projects here discussed are not yet far enough advanced to be entirely satisfactory as examples. The results to date, however, are so promising and the method so plausible that others working with small grains may find it worth considering when breeding for definite ends.

Smooth-Awned Barley

One of the barley projects now under way is the production of varieties with smooth awns. This is of especial interest because both the large generation and the back-cross methods have been and are being tried. The extensive co-operative breeding work at the Minnesota Agricultural Experiment Station was carried on by selections in the F_2 and later generations. This work is being continued. At two other experiment stations the production of smooth-awned barleys is an important project. The production of high-yielding smooth-awned varieties is of much importance. The rough awns are objectionable both in harvesting the crop and in feeding the straw. They definitely limit the acreage of barley in places where the acre yield of feed from barley exceeds that of the crop grown in preference.

Several smooth-awned barleys have been imported into the United States. Most of these are black, six-rowed, hulled varieties. Crosses with these and the American commercial varieties were first made by the senior author in 1911 and 1912. In 1913 an F_2 population was grown at St. Paul, Minn., in co-operation with the Minnesota Agricultural Experiment Station. In later years other F_2 populations were grown and a large number of segregates tested. The crosses at St. Paul were with barleys of the Manchuria type. In the Western States, hybrids with the barleys adapted to arid regions were made. Although the stocks of smooth-awned barleys available for hybridization were inferior in yield to Manchuria or the Western forms, out

of a cross of smooth-awned × Club Mariout a smooth-awned segregate was found equal to the Club Mariout parent in yield. This work was done at Moro, Oregon, in co-operation with the Oregon Agricultural Experiment Station. At St. Paul, Minn., no segregates of the Manchuria × smooth-awn crosses have so far been equal to the Manchuria in yield. As the senior author has previously stated,[1] it is unlikely that a parent is ever exactly recovered among the segregates of a cross and it is probable that weaknesses not found in the Manchuria parent were present in all segregates tested.

In 1920 it occurred to the senior author that, as all that was desired was a smooth-awned Manchuria, this character could be effectively transferred to the best Manchuria strain by backcrossing. C. I. No. 2330 (Minn. No. 184), the best Manchuria selection developed by the Minnesota Agricultural Experiment Station, was used as the Manchuria parent. A white six-rowed smooth-awned segregate from a previous cross was used as the smooth-awned parent. This segregate was homozygous for smooth awns and was one of the best of those tested at Minnesota. It was already partly of Manchuria "blood."

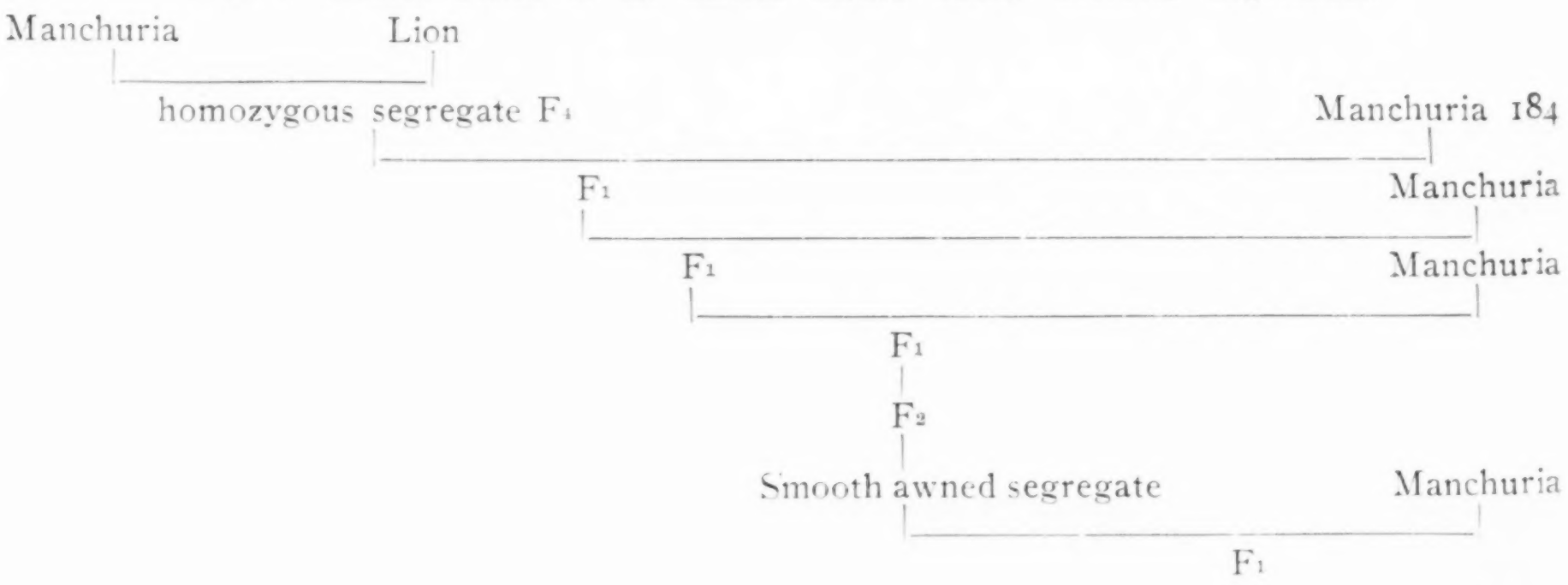
In the winter of 1920-21 the parents were crossed in the greenhouse at Arlington Experiment Farm, Rosslyn, Va. The F_1 of this cross was grown at Aberdeen, Idaho, in 1921, where it was recrossed with C. I. No. 2330, the Manchuria parent. The recrossed seed was sown in the greenhouse in the fall of 1921 and the F_2 generation grown at Aberdeen in 1922. A smooth-awned segregate in 1922 was crossed again with C. I. No. 2330 and the resulting seed sown in the greenhouse. The status of this project today is shown graphically below.

Results Obtained to Date

Already the barley looks more like Manchuria than any obtained previously from other crosses. It has been obtained quickly and inexpensively, as the numbers used were very small. It is in a way a project where the breeding of resistance to diseases occurring in Minnesota has been a factor and where the actual work has been done remote from this environment. It will be interesting to note if resistance can be obtained under such conditions.

This opens the question of the relative value of the two methods of breeding. This in turn brings up the large question of the reason for the lack of complete success in the earlier attempts. In this case the object is to obtain a smooth-awned barley as good as Minnesota No. 184 (C. I. No. 2330). From the smooth-awned parent we want only the smooth awns. All the

Chart 1. Present Status of the Smooth Awned Barley Breeding Experiment.



[1] HARLAN, HARRY V. Smooth-awned barleys. *Journ. Amer. Soc. Agron.* Vol. XII, Nos. 6-7, 1920, pp. 205-208.

other characters, morphological and physiological, are desired from the Manchuria parent. How feasible it may be to secure by recombination the characters of a parent is difficult to answer. Inheritance studies necessarily involve characters that can be measured or evaluated. Most of these are morphological in nature. Occasionally a physiological detail of metabolism becomes evident through chance, as when anthocyan colors are formed. The number of variations in metabolism which are not thus revealed cannot even be guessed at, but must be large. We do know that variations in the protoplasmic complex are inherited. That the difference of the cell content of varieties is evidenced in many ways, such as the treatment necessary to coagulate the proteids of wort from barley; the variations in milling quality in wheat, and recently by the specialized forms of rust. Following the lead of Dr. Stakman, 37 specialized forms of stem rust now are known and the number seems limited only by the facilities for testing. These forms are largely differentiated by the reaction of different strains of wheat to them. This means that there now are known 37 different heritable protoplasmic complexes of wheat that have to do with rust resistance. It is probable that several times that number actually exist. There must also be many heritable variations of cell content not associated with rust resistance but associated with the vigor and yielding power of the plant and with the nature of the proteids in the grain which may be of importance in milling, malting, or other commercial use.

At any rate, in the mating of two parents there is an indefinite number of heritable physiological characters that will combine in an unknown number of combinations and the nature of these combinations cannot be determined by an inspection of the plants, as is the case with morphological characters. We are thus breeding for characters we cannot see and whose numbers we do not know. This brings up the question of probabilities. If we are dealing with an unknown number if invisible characters, what is the chance of securing a segregate that has all the Manchuria characters except roughness of awns? When our pathologists get under way on the leaf and root fungi detrimental to barley it is probable that they can equal in number the rapidly increasing parasites of wheat. When to the number of different protoplasmic complexes shown by disease susceptibility is added those differences which must be associated with other heritable qualities the number of non-visible factors may reach into the hundreds. If there were only 20, the breeding by the use of large numbers would be impossible, assuming that all 20 of the physiological characters of Manchuria are superior to those of Lion for conditions in Minnesota, and that these are inherited independently. There would be just one chance in 1,048,576 that the 20 desirable Manchuria characters would be found in any segregate and one chance in four that this segregate would be smooth-awned if found.

It obviously would be impossible to grow such a generation or to discover the desired plant if grown. On the other hand, in back-crossing, if the 20 characters are inherited independently, there is a rapid elimination of those coming from the Lion parent. With each recross the Lion "blood" is reduced one-half; in five back matings only one-sixty-fourth of the blood is not Manchuria and that one-sixty-fourth is heterozygous with only one chance in 128 of any one factor being finally other than Manchuria. That is, if there were 20 independently inherited factors the expectancy would be for 108 out of 128 plants to be entirely homozygous for Manchuria characters and the remaining 20 to be heterozygous for only a single character. It should be possible here to select the plant desired.

Linkage a Limiting Factor

These assumptions are based on independent inheritance. The assumption of independent inheritance is no more justified than the assumption of as few as 20 characters. It is probable that these factors are linked in groups and that the groups are fewer than 20 regardless of the total number of factors. This assumption, while decidedly influencing the results obtainable, does not change the method of procedure. If linkage is presumed, it is logical to presume that some of the objectionable characters of Lion are linked with the smooth-awned factor. If this is the case it limits the achievement of all methods of breeding and if the linkage cannot be broken down the best that can be achieved will be smooth-awned barleys homozygous for the factors of Manchuria except those with which the smooth awn is linked in Lion. This point, if it is the limit, should be more easily reached by back-crossing than by selection from an extensive F_2 generation.

There is no reason to believe that linkage is at all an insurmountable barrier. Other smooth-awned parents could be used in which more desirable characters might be linked with smooth awns than in Lion. Also linkage is far from absolute. In the continued back-crossing there is opportunity for cross-overs to break up the undesirable group. As the Manchuria parent is repeatedly used, cross-overs must include desirable characters, which is not necessarily the case in the later generations of the heterozygous elements of the cross when not back-crossed. In many plants the evidence of linkage is so slight as to indicate a very great number of cross-overs.

Whatever the explanation, it would seem that on this project the easiest approach to the point limited by linkage is by back-crosses and that the greatest opportunity for profitable cross-overs is afforded by the same method. In the smooth-awned project the smoothness of the awns is not being modified by the repeated back-crossing. The F_2 plant segregated out in 1922 had awns as smooth as those of the parent used in 1920.

The writers have one or two other breeding projects where the same method is being used and it would seem especially serviceable in such problems as changing the color of otherwise desirable varieties and in securing earliness while retaining the varietal characters.

Group, Race, and Nation

THE GROUP MIND, a sketch of the principles of collective psychology with some attempt to apply them to the interpretation of national life and character, by WILLIAM McDOUGALL, F. R. S., Professor of Psychology at Harvard University. Pp. 418. New York, G. P. Putnam's Sons, 1920.

One of the distinguishing features of Dr. McDougall's extremely interesting book is the sound eugenic theory which runs through it. The eugenist must be profoundly concerned with many of the facts of collective psychology, since he is dependent on them to get carried into effect the principles which he realizes as essential in any permanent and good government. Dr. McDougall has, from the psychological side, made many helpful contributions to eugenics, and the present volume, which is a sort of sequel to his widely-known *Introduction to Social Psychology*, deserves wide reading.—*P. P.*

DIVERSITY OF INTERNODE INDIVIDUALS

O. F. Cook

Bureau of Plant Industry, U. S. Department of Agriculture

DATA of special value in the study of diversity may be drawn from plant life or from such lower animals as worms, millipeds, or centipeds, with the body showing numerous repetitions of the same organ. Dozens or hundreds of joints of a metamerous plant or animal body may follow each other as exact biological equivalents, and such series may be considered as the closest approach to uniformity in the processes of reproduction. Since the metamers are products of segmentation or vegetative growth, the problem of interpretation is greatly simplified. Many physiological and environmental complications attend sexual reproduction, with endless possibilities of confusion regarding the heredity of sexually produced individuals. The individuality of the vegetative internodes is of a lower order, but lends itself better to a determination of the question of diversity.

That internode members of the same plant are formed under the same conditions and are of the same heredity, is hardly to be questioned. At least, it will be admitted that the conditions of internode development are more alike in the same plant than can be asserted for different plants. Of course, the vegetative internodes may be specialized in various ways and degrees, as are the internode components of the flowers and fruits, so that numerous types of internodes may be distinguished among the internode members of a plant, but hundreds or thousands of examples of the same type may be available for comparison in a tree, shrub, or large plant.

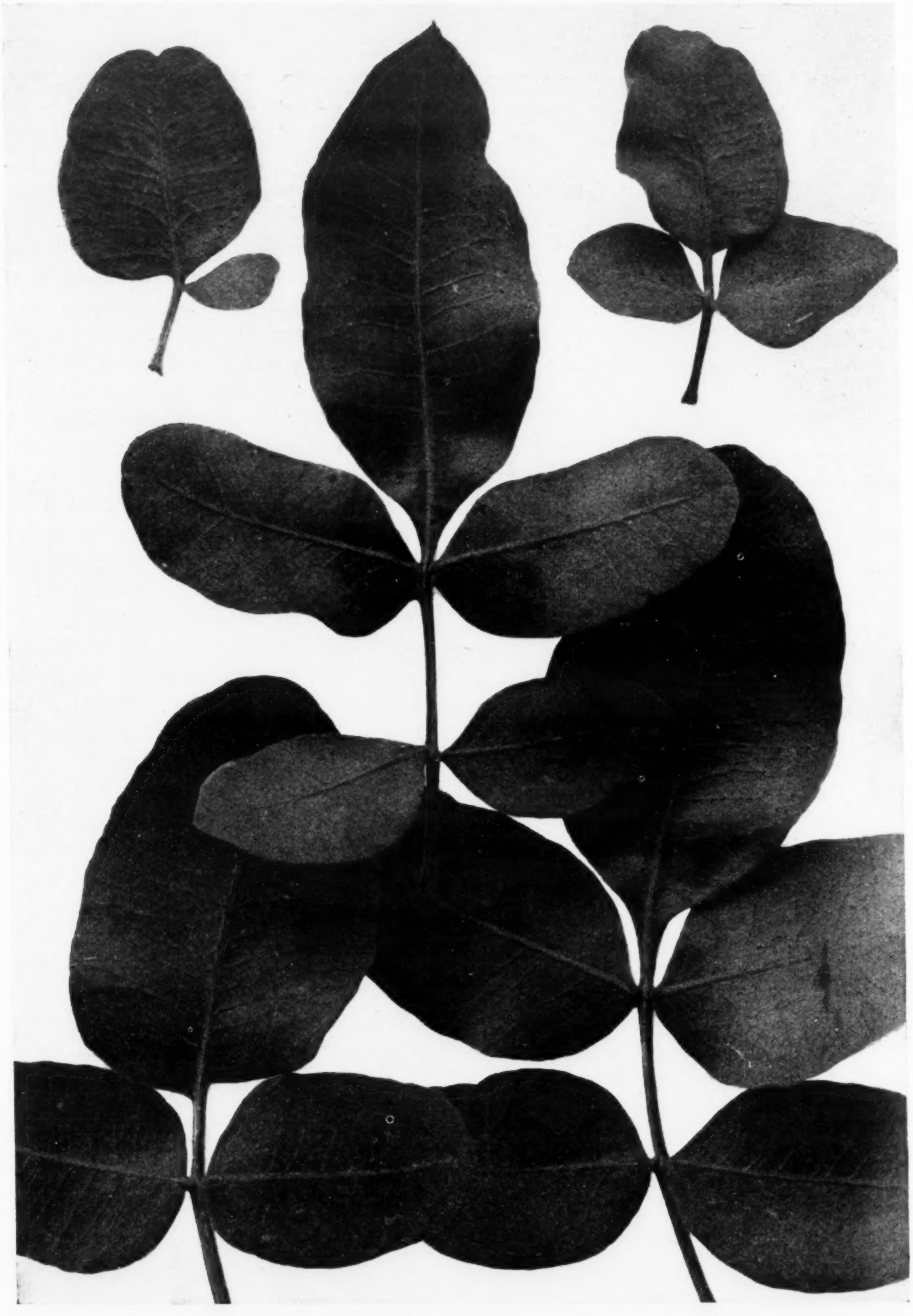
Biological Duplication

Not only do successive internodes or leaves of the same vegetative shoot represent biologically the same thing, but comparison of the two halves of the same leaf or other symmetrical parts of the same internode individual gives even a sharper focus upon the question whether biological duplication or manifolding of the same structure is a process of mechanical exactness or may follow many alternative courses, with a resulting diversity of detail.

Whether we think of a transmitted "character" as a general "determiner" of leaf-form for the entire plant, or as restricted to a particular feature, or to an individual leaf, exact determination is hardly to be claimed when definite differences are shown by corresponding parts of the same leaf. (See figures 19 to 22.)

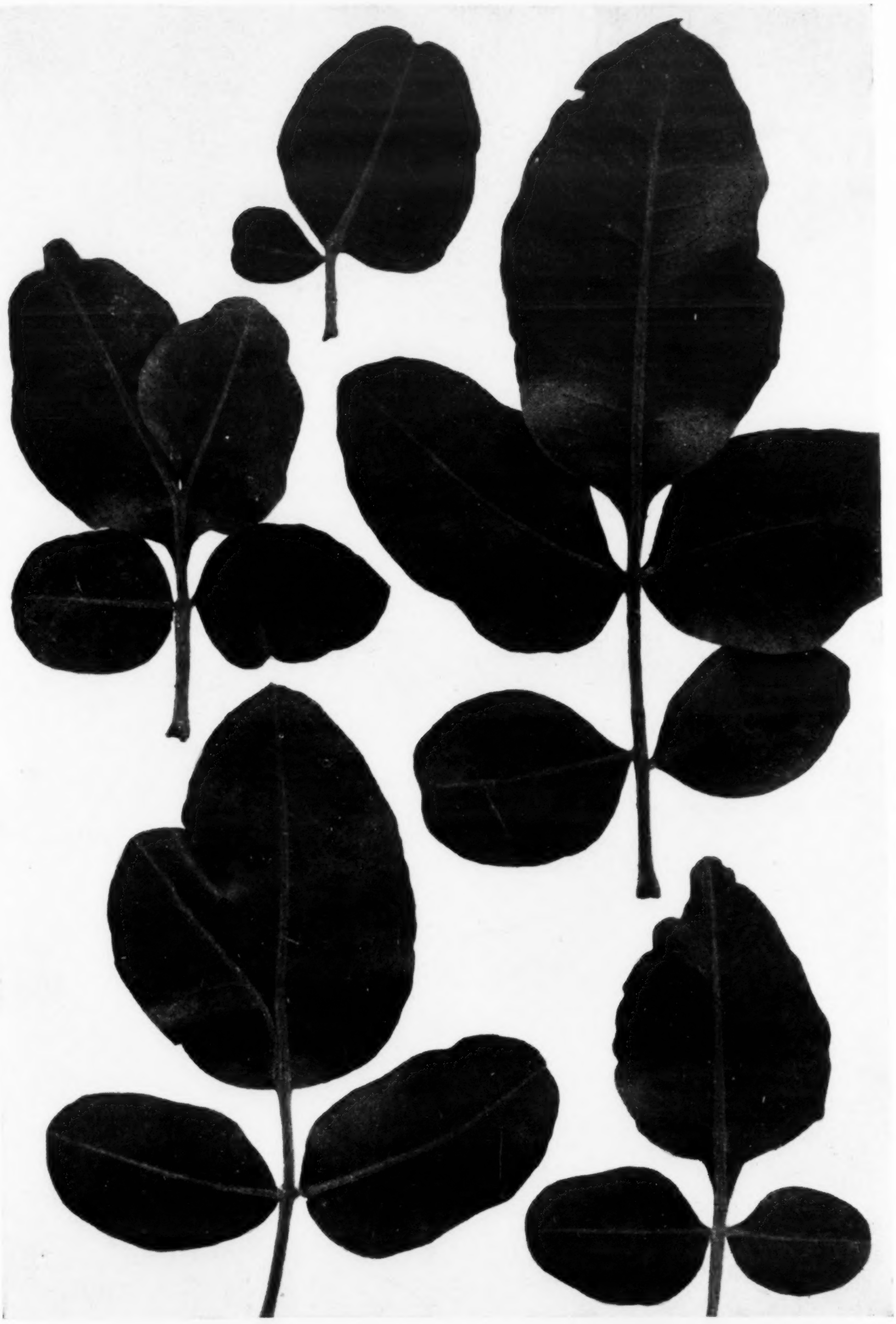
The meaning of such facts in relation to heredity depends, of course, on the assumptions that are made regarding the nature and number of the transmitted determiners or "genes." In proportion as fewer determiners are assumed for the transmission of the characters a wider range of diversity must be admitted in the expression or development of the characters, to account for differences among the internode individuals of the same plant. The course of internode development is not simple and direct, but divides and ramifies into the many alternative paths that are shown in the formation of the different types of internodes, as well as in the diversity of form that appears among the internode individuals of the same type. Even in the same leaf, diversity may be shown, when equivalent parts are compared.

The different types of internodes on the same plant may be as different as species, genera or families, or may be considered as analogous to the sexes, castes or other definitely diverse forms



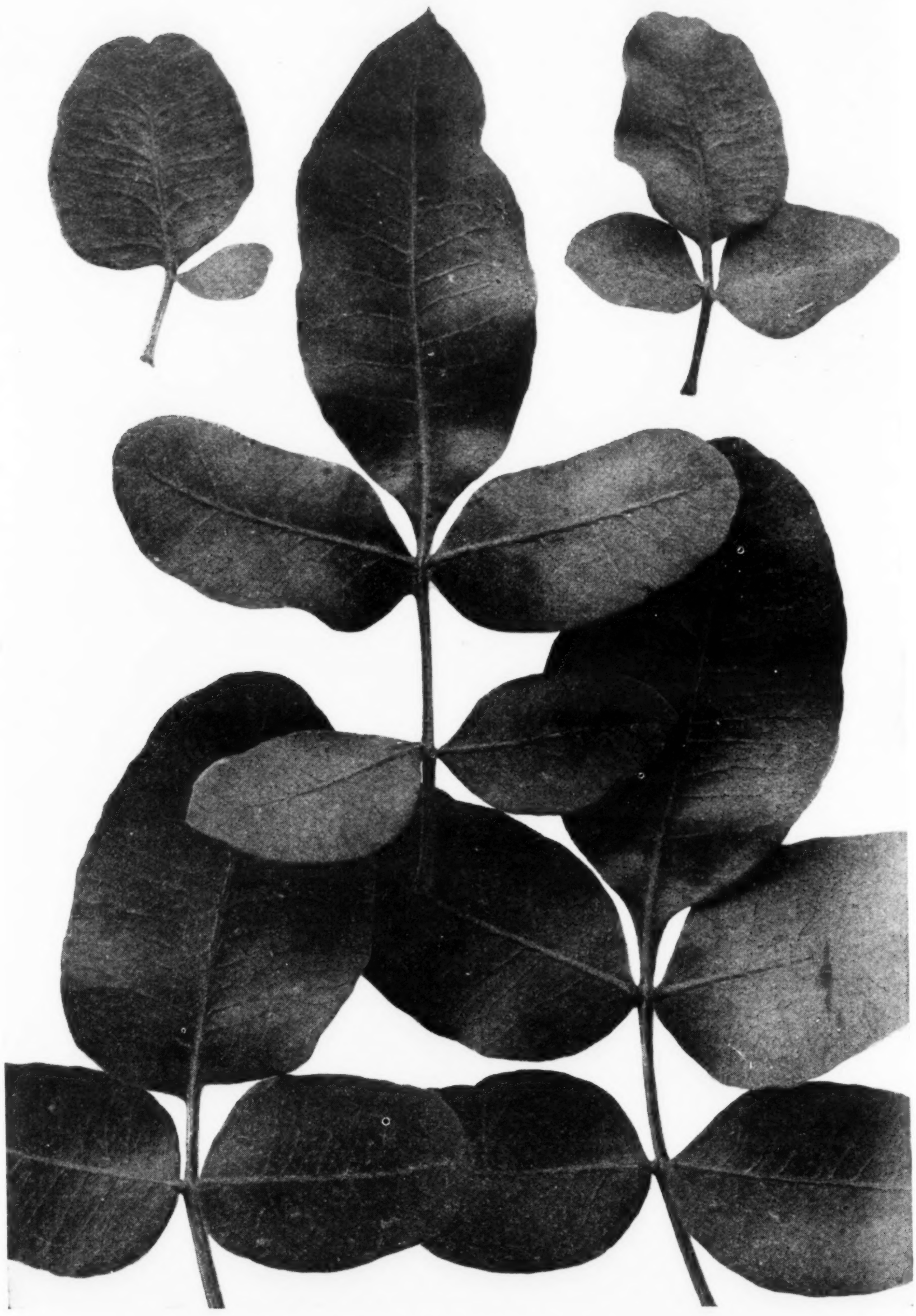
DIVERSITY OF LEAF-FORMS IN PISTACIA

FIGURE 19. Leaves of the pistachio tree (*Pistachia vera*) at Sacaton, Arizona, October, 1922, all from the same tree as Figure 20, the three large leaves from the same twig. The typical leaf-form is shown at the lower right-hand corner, a leaf with two pairs of lateral pinnae which are narrowed abruptly to the point of attachment while the terminal pinna has a gradually narrowed or decurrent base. Leaves with only one pair of lateral pinnae often show a more abrupt narrowing of the base of the terminal pinna which in such cases probably indicates a complete fusion of the upper pair of lateral pinnae with the terminal pinna. Different stages of partial fusion are shown, as in Figure 20. Natural size.



DIVERSITY OF LEAF-FORMS IN PISTACIA

FIGURE 20. Leaves from the same tree as in Figure 19, showing intermediate stages between leaves with one pair and two pairs of lateral pinnae. The second pair of lateral pinnae often is fused more or less completely with the terminal pinna. The lower left-hand leaf shows partial fusion on one side and complete fusion on the other, as indicated by the very abrupt base, which is a character of the lateral pinnae. In the upper left-hand leaf the decurrent base character is shown in the lateral pinnae, one of which is separate and the other completely fused with the terminal pinna. Such fluctuating differences in leaf-form are of interest as showing that the processes of heredity are not exact, but result in normal diversity.



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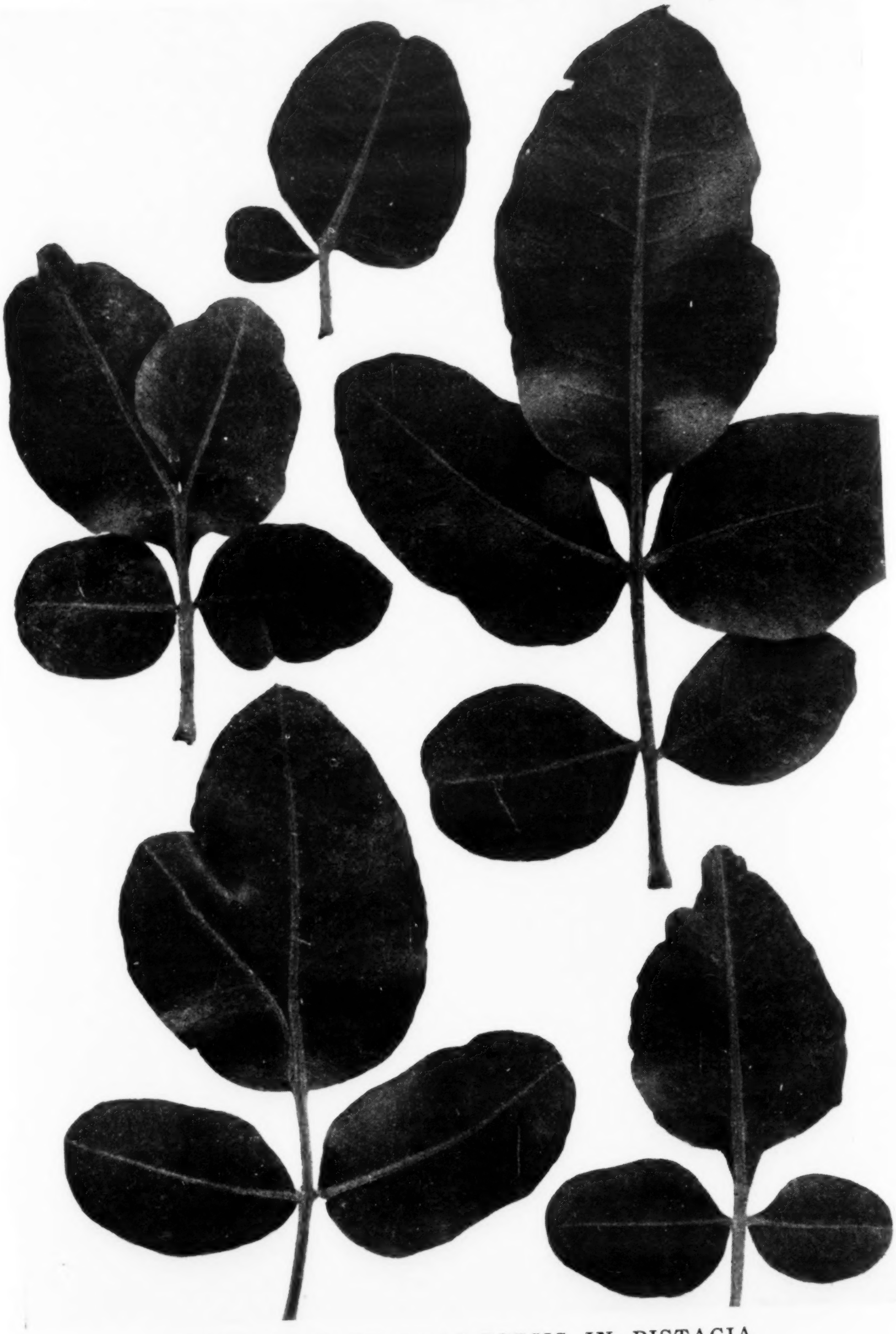

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FIGURE 20. Leaves from the same tree as in Figure 19, showing intermediate stages between leaves with one pair and two pairs of lateral pinnae. The second pair of lateral pinnae often is fused more or less completely with the terminal pinna. The lower left-hand leaf shows partial fusion on one side and complete fusion on the other, as indicated by the very abrupt base, which is a character of the lateral pinnae. In the upper left-hand leaf the decurrent base character is shown in the lateral pinnae, one of which is separate and the other completely fused with the terminal pinna. Such fluctuating differences in leaf-form are of interest as showing that the processes of heredity are not exact, but result in normal diversity.

DIVERSITY OF LEAF-FORMS IN AGRIMONIA

FIGURE 21. Leaf of Agrimonia growing in partial shade at Lanham, Maryland, showing diversity among the pinnae, with many gradations in size, and irregular alteration of arrangement. Groups of one to four of the small pinnae alternate with the large pinnae. The larger of the small pinnae are generally at the intermediate positions, between the bases of the large pinnae, but these relations are not regular, nor are the shapes or the marginal notches of the pinnae.

DIVERSITY OF LEAF-FORMS IN AGRIMONIA

FIGURE 22. For comparison with Figure 21 to show the nature of the differences that commonly appear among leaves of the same plant. The rachis of this leaf is longer and the pinnae more slender and widely spaced, also differently graded in size, with some of the secondary pinnae relatively larger, especially on the left side of the leaf. Also the upper, left-hand pinna is decurrent at base, possibly as a result of being united with a small pinna.

that become established in many species. But in addition to these larger differences the internode individuals of the same type show a general diversity corresponding to that of individual plants or animals which are members of the same species. Thus the most direct indications of biological facts do not support the idea of definite paths of development, or of paths that are followed exactly. The inference is that diversity, rather than uniformity, should be considered as the normal product or manifestation of heredity. The different types of internodes of the same plant were considered by Goethe as an important evidence of evolution, and a like significance may be claimed for internode diversity in relation to heredity.

Having seen that the expression of characters is frequently and indefinitely varied in the development of the internode individuals, it seems not unreasonable to expect a similar variability in sexually produced individuals, and to consider such diversity as a result of normal reproductive processes. Goethe described the growth of internodes, one from another, as "successive reproduction," in contrast with "simultaneous reproduction" by sexual processes.

Notwithstanding the great advances that have been made in recent years in the cytological study of transmission and the mechanical explanation of the inheritance of Mendelian differences, there still is no conception of the nature of the characters, as showing how they are represented in transmission, or how they are brought into expression. Hence it is possible as yet to think definitely of characters only as they are brought into expression, through the development of the plant or animal individual. The results that are produced are the only basis of judgment regarding the nature of the reproductive processes, the transmission and expression of the characters.

A Survey of the Whole Field

READINGS IN EVOLUTION, GENETICS, AND EUGENICS, by HORATIO HACKETT NEWMAN, Professor of Zoology in the University of Chicago. Pp. 253, with 101 illustrations; price $3.75. University of Chicago Press, 1921.

That this volume has passed through several impressions since its first publication, is good evidence that it meets a need of the collegiate world. It consists of extracts from the works of standard biological writers, living and dead, together with numerous introductions and discussions by Professor Newman, covering all the important phases of the subjects included in the title. The sections dealing with what are now more or less historical aspects of genetics are full enough to leave the uninitiated reader in some doubt, perhaps, as to just how far they have stood the test of criticism, and subsequent development of the subject. It is perhaps inevitable that some topics should be dealt with by writers who are by no means recognized as masters of them, though perhaps eminent in some other field of biology. Difficulties like these are certain to occur in any book made of selected readings, and if they require elucidation, the instructor will doubtless be able to supply it. On the whole, the book is probably the most useful single volume available to a reader seeking merely a brief account of all aspects of genetics.—*P. P.*

CULTURE OF CREPIS FOR GENETIC INVESTIGATIONS

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IN genetic investigations dealing with living organisms the problems of cultural technique are of prime importance. The methods must permit of facility and accuracy in manipulation and at the same time give equal and optimum conditions for the development of all individuals. In most breeding work, such technique is only developed after a period of trial and comparison by which unsuitable methods are discarded.

Preliminary experiments indicate that some species of the genus Crepis, particularly those with low chromosome numbers, give promise of becoming the means of inquiring into problems of cytology, the evolution of chromosome number, speciation, and heredity in plants. Since a number of inquiries concerning technique have been received it seems desirable to describe some of the cultural and hybridization methods which have been employed by the Division of Genetics at the University of California in preliminary experiments with Crepis plants.

The genus belongs to the chicory tribe or Liguliflorae of the Compositae which includes all those plants having a flower capitulum composed entirely of ligulate flowers. In *Crepis capillaris* each flower is perfect, 30 to 50 being grouped to form a single capitulum which when open measures about 20 mm. in diameter.

Although the cultural and hybridization methods reported here have been used on relatively few species, they may be adapted for use on any of the small-seeded plants of this group.

Germination of Achenes

The achenes are very small and the seedlings on first appearance may closely resemble those of some weeds, therefore, the method of germination must be so devised as to permit no uncertainty regarding the identity of the seedlings. This has been provided for in two ways, one of which is steam sterilization of the soil in shallow clay seed pans at 15 pounds pressure for 45 to 50 minutes. Before sterilization a piece of paper is tied over the top of the seed pans and it is not removed until the achenes are planted, thus eliminating chances of contamination if seeding is delayed for some time after sterilization. The achenes are sown in the pans and covered as in the usual practice for seeds of this size. About the time the second plumule leaf appears the seedlings are pricked out and planted in six-inch clay flower pots, or into smaller pots or flats, if the plants are to be grown as field cultures. In the second method the seeds are placed in a small moist-chamber germinator shown in figure 23, suitable for any number up to 100 achenes.

Glassware and paper should be sterilized to prevent the growth of fungi in the moist chamber. This latter method has an advantage over the sterilized soil by permitting inspection of the sprouting achenes, an accurate record of the percentage of germination, the examination of achenes that fail to germinate, and a record of the sequence of germination. As the achenes germinate they can be taken up with a fine pair of forceps and planted in pots or flats. In order to avoid injuring the tender seedlings by handling with the forceps, a small portion of the damp towel paper may be lifted with the seedling adhering to it. This fragment of paper is placed in the soil with the plant, the forceps not coming in contact with the seedling at any part of the process. Some achenes which remain

MOIST CHAMBER GERMINATOR

FIGURE 23. An easily made and efficient germinator for sprouting the delicate Crepis seedlings. It is made by folding a paper towel over a piece of flat glass and letting the ends dip into water. The seeds are covered with an inverted petrie dish.

for days in the germinator without sprouting can sometimes be made to do so by splitting the seed coat. The germinators should be placed in subdued light, inasmuch as the light tends to retard lengthening of the root and hypocotyl, making it more difficult to get the seedling into the soil properly. The intensity of the light may be reduced by placing over the germinators several thicknesses of newspapers. Under such conditions the hypocotyl elongates so as to facilitate handling and planting. The achenes will germinate under a wide range of temperatures but from 60° to 70° F. gives most satisfactory results.

With such small seedlings some difficulty may be encountered when the watering is done from above when either a hose or sprinkling-can is used, because of soil being washed over the seedling. This may be avoided by placing the pots in shallow pans which are then filled with water. The water enters the pot through the drainage-hole in the bottom and is carried upward to the surface by capillary movement. For the first few days the top of the pot may be covered with a piece of glass which will check surface evaporation. A relatively small number of pans may serve for a large number of pots inasmuch as the pot needs to remain in the water only ten to twelve hours to be thoroughly irrigated. The pans may then be shifted to serve in watering another group of pots. When the plants are about four or five weeks this sub-irrigation may be dispensed with.

For field cultures the seedlings can be placed in 2″ x 2″ x 2″ bottomless tar paper planting pots (obtainable at seedsmen's supply houses), and later, when the rosettes start to form, placed in the field rows; or the seedlings can be placed in flats without using the paper

pots. However, the later are more satisfactory.

Different forms of fungus may appear and grow very rapidly in the moist chamber of the germinator, the spores having been introduced with the achenes. Achenes are sometimes retarded or entirely prevented from germinating by the presence of fungi in the germinator. Although it is not always necessary, in special cases of limited supply of seed it may be desirable to treat the achenes to prevent fungus development in the germinator. Formalin vapor and calcium hypochlorite have been used effectively for this purpose, but any of the common methods of seed sterilization may be used.

Technique of Hybridization

The smallness and peculiar arrangement of the flower parts in Crepis require, for critical hybridization work, especially devised methods of manipulation. Mendel attempted some hybridization work on Hieracium, the flowers of which are essentially like those of Crepis. He found that the failure to secure a large number of hybrids was largely due to the minuteness of the flowers, to their peculiar arrangement, and to the fact that it was seldom possible to remove the anthers without injuring the pistil.

Although the flowers of *Crepis capillaris and C. tectorum* are no larger than those of Hieracium the difficulties mentioned by Mendel have now been largely overcome by growing plants in the greenhouse where humidity can be controlled, and by using especially adapted tools for the work. The most useful of these is a binocular magnifier, which can be attached in place before the eyes of the operator, thus leaving both hands free. Microscopes of this type can be obtained from optical companies.

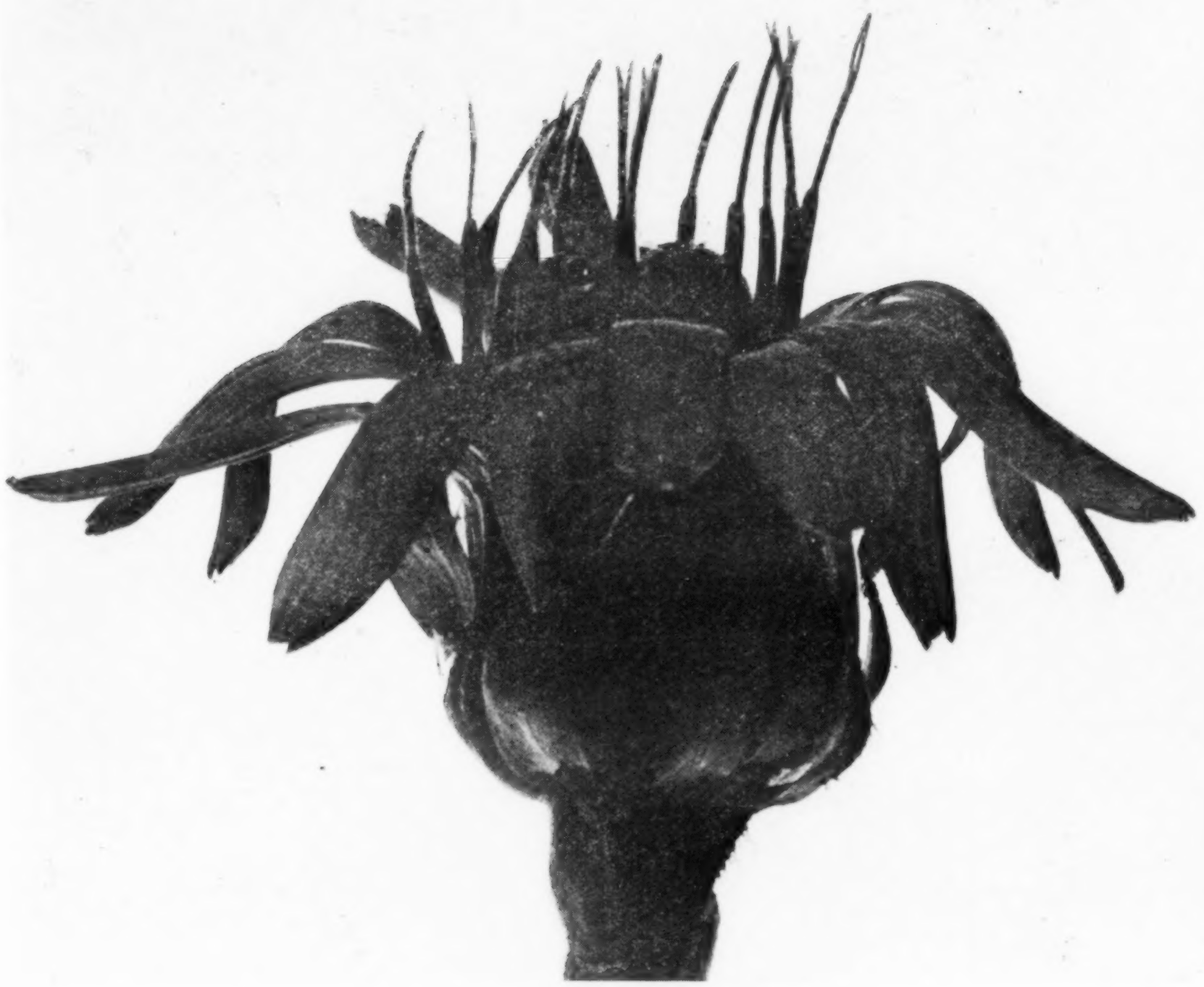
In *C. capillaris*, the anthers are removed just before the flowers of the capitulum open, when the bud is about 7 mm. long. When the flower is fully open about half of this length is bent back so as to be in a plane at right angles to the pedicle. Individual flowers when fully expanded are from 10 to 12 mm. long. The length of the pistil is slightly less than that of the corolla. The stamen tube of a fully open flower is 3 mm. in length. The flower at the stage when emasculation is performed is but 5 mm. long. Flowers of the Compositæ have five anthers, which form a tube about the style, the pollen being shed on the inside of the tube. As the flower begins to open, the style elongates, pushing the two closely appressed stigma lobes upward through the stamen tube until they extend above it, when they spread apart and are later pollinated. The upper portion of the surface of the style and the outer surface of the stigmas are supplied with barbs pointing upward, which sweep the pollen out of the tube as the style elongates. The stigmatic lobes of the style usually remain together until the floret is fully open, and the style fully extended, thus preventing self-fertilization from taking place before there is a chance for cross-fertilization. If they fail to be cross fertilized, the stigmas curl in such a way that the receptive inner surface of the stigma comes into contact with its own pollen or that of an adjacent floret so that fertilization may result.

Two methods of pollen removal referred to in a previous paper (2) have been used. The first method consists in removing the pollen from the stigmas of the entire head, by forcing a fine jet of water over them from the nozzle of a small dental chipblower syringe, much after the method described by Oliver. Due to the fact that anthesis occurs progressively from outer to inner florets of the capitulum, this method was not satisfactory, because it would require close attention for a number of hours on several successive days to insure the removal of the pollen from all the florets.

A modification of the Oliver method has been devised which reduces the time and attention required for a given pollination, and with which the probability of self-pollination is reduced to a minimum. In this method only the outer whorl, containing about 20 florets

HYBRIDIZING TABLE

FIGURE 24. The support for the pot is adjustable, permitting the flower to be brought to any desired level. Much of the work with Crepis is of a very minute character, and a binocular magnifier that can be worn on the head is of great assistance. Crepis is of value to the student of heredity because of the small number of chromosomes its cells contain, making a study of the location of hereditary characters within the chromosome a relatively simple matter.



A CREPIS FLOWER

FIGURE 25. Only the outer whorl of florets has opened. At this stage pollen would be removed from the anthers and the unopened florets would be pulled out, if this flower were to be used for hybridization experiments. Greatly enlarged.

is utilized, the rest being pulled out with a pair of fine pointed forceps before anthesis takes place. The efficiency of the improved water depollination method has been well demonstrated in attempts to cross species of which the female, at least, is self fertile, but sets no seed after pollination with foreign pollen. Heads not depollinated set seed abundantly.

Anthesis occurs during definite intervals of the day. In the species under discussion from three to five days are required for all of the flowers of a capitulum to open. The outer whorls of florets become active first; the others follow in order from the outer to the innermost. During clear warm weather anthesis of a whorl of florets commences before seven o'clock in the morning and ceases about half past eleven the same morning. It is first evidenced in a bud by the rapid elongation of the outer whorl of florets. They remain at the maximum elongation for a short period and then rapidly open. Activity in the process of anthesis apparently is suspended during the afternoon and until about the same time the following morning when it is renewed. During this period of suspended activity the florets tend to remain in whatever stage they happen to be until the active period of the next day. Thus sometimes only a few of the florets of the first whorl expand during the first active period, the rest remain inactive until the following day. Similar behavior has been noted by

BEFORE AND AFTER DEPOLLINATION

FIGURE 26. Two Crepis florets greatly enlarged, showing the effect of the water depollination process.

Fruwirth in the common chicory, *Cichorium Intybus*.

Weather conditions may cause a variation in the time of these periods of anthesis activity. They are more clearly defined during clear sunny days than during cloudy days. Opening of the florets takes place during the forenoon and fifteen to twenty florets (those of the outer whorl) develop first, while the remaining inner florets show no activity. Hence with the improved water depollination method the pollen can be washed from the stigmas of the outer whorl of florets before the stigmatic surface is exposed. The central florets, which have not yet begun to open are then pulled out. From one to three days later pollen may be applied to the exposed stigmatic surfaces of the depollinated florets and the heads enclosed in a paper bag. Usually, however, the head is again pollinated on the two succeeding days to insure fertilization. This method has given satisfactory results.

Another method used for the most critical hybridization work is the actual removal of the undehisced stamen tube from the unopen floret. This operation is performed under a binocular magni-

fier giving a magnification of three to five diameters. A larger magnification might be desirable, but to secure this would mean a reduction of the working distance and a finer adjustment of focus making it very difficult to perform the work with the binocular worn on the head of the operator. The involucral bracts which inclose the florets in the bud stage are bent down and held out of the way during the operation. The back (or under) side of the corolla thus exposed is slit almost its entire length using a dissecting needle having a very small sharp pointed hook at its tip. The stamen tube is likewise split, often at the same time that the corolla is opened. With the hook at the point of the needle the split stamen tube is pulled from its position surrounding the style, the upper end is grasped with finely pointed forceps and removed by a gentle upward pull. The operator can, after a little practice, perform this without breaking the anther tube, as the fine filaments will break before the stamen tube itself. Some of the pollen grains may adhere to the style, and to remove these the emasculated flowers are flushed by a stream of water as in the water depollination process. Ordinarily only the peripheral whorl of florets are emasculated, the remainder, because of their greater inaccessibility and immaturity, are pulled out. The bracts of the involucre are then folded over the florets and the head enclosed in a small bag.

When the florets have opened from one to three days later, the heads should be carefully examined for any unemasculated florets which may have escaped removal. If any open florets are found, the entire head should be discarded; if none are found, pollen is applied by brushing the anthers of a previously bagged pollen plant over the receptive stigmas of the emasculated florets. It may be desirable to modify this procedure to take advantage of some particular characteristic of some of the other Crepis species. Thus in *C. rubra* it is sometimes possible to remove both corolla and stamen tube at one operation by grasping the upper end of the ligule at an early stage of anthesis and pulling upward steadily and slowly. These parts are detached from the achene and come off leaving the style free of pollen and the stigmatic surfaces still unexposed. For the emasculation work the ordinary dissecting needles and forceps are very much too coarse and blunt. If satisfactory tools cannot be purchased they can be made by grinding down the points, and finishing them under a binocular in order to secure a fine smooth point on the needles and perfect alignment to the tips of the forceps.

To facilitate the emasculation work, a table has been designed with arm supports similar to the arm supports of a dissecting microscope and an adjustable support for the potted plant which may be raised or lowered so that the buds of the plant can be brought to the level most convenient for the operator.

Abundant pedigree seed of the self-sterile or partly self-sterile species and biotypes may be best secured by dusting the pollen of one plant onto the stigmas of another of the same strain. Some of the strains, due to a high percentage of self-sterility can only be maintained in this way. Self-fertile plants may be protected in the field by using a cheese cloth covered box, but this method is rarely satisfactory for the greenhouse. Semi-transparent waxed paper bags are more desirable than opaque fibre bags. The achenes mature from 3 to 4 weeks after pollination and can be made to germinate without a rest period.

Parasitic Organisms

Crepis plants may become infested with parasitic organisms common to greenhouse and cultivated plants and these may be eradicated by the usual methods. During damp, cloudy or rainy weather the greenhouse cultures may be attacked by a fungus (*Botrytis cinerea*) causing damage to foliage and frequently causing death of plants. Reduction of atmospheric humidity seems to be the most effective way to combat the spread of this fungus.

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MEMORIAL TO JAMES REID

Originator of "Reid's Yellow Dent," the Most Valuable Type of Corn Ever Produced

Members of the American Genetic Association will be interested to learn of the formation of the "James Reid Memorial Association."

The objects of the association are to honor the memory of this great plant breeder and to provide a fund for the relief of his wife and daughter who are in need.

The plan provides that after their death the fund, to be known as the "James Reid Fellowship Endowment," shall be intrusted to the University of Illinois and the proceeds of which are to be used to encourage research work on corn.

"Reid's Yellow Dent," the variety developed by Mr. Reid, is believed to be the most valuable strain of corn that has ever been produced. The initial steps in the production of this variety were taken by Mr. Reid's father, who began the work by crossing two distinct varieties of yellow corn. From the results of this cross Mr. James Reid by years of patient selection produced the variety that proved to be well adapted to a wide range of conditions and has served as the foundation of a host of local varieties. The type was so prepotent that in spite of hybridization and selection to meet varying conditions the results of Reid's work are still plainly evident in a large part of the yellow corn now being grown.

Those wishing to add to the fund may send their contributions through the American Genetic Association, Box 354, Pennsylvania Avenue Station, Washington, D. C.